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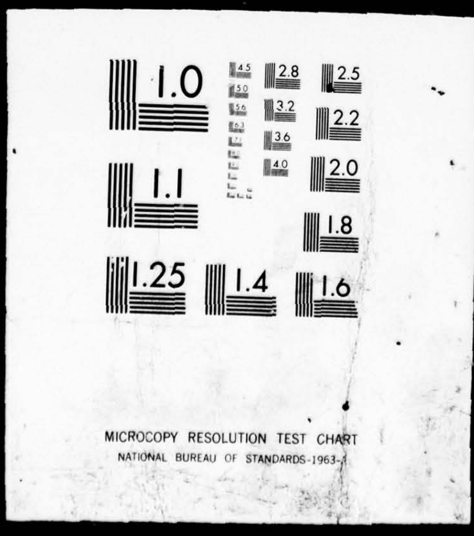

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LEVEL II

AIRCRAFT AIR POLLUTION EMISSION ESTIMATION TECHNIQUES-ACEE

HAROLD A. SCOTT, JR.
DENNIS F. NAUGLE
ENVIRONMENTAL SERVICES DIVISION-
ENVIRONMENTAL MODELING

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A five-step analytical methodology is presented that can be adapted to nearly any aircraft related air quality assessment problem. The methodology is for use by base level environmental personnel to calculate (1) annual aircraft emissions and (2) downfield pollutant concentrations. The latest individual engine emission factors and other information required for the methodology are contained in this report.

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PREFACE

This final report was prepared by Det 1 AFESC Civil and Environmental Engineering Development Office (CEEDO), Tyndall AFB, Florida. This work was accomplished under Job Order Number 21035A28; Lt Harold A. Scott, Jr. and Capt Dennis F. Naugle were the project officers.

The methodology presented in this report was developed to enable base level environmental personnel to calculate annual aircraft emissions and estimate the aircraft's air pollution concentrations near the base. The information required to perform the air quality analysis methodology was accomplished using the Air Quality Assessment Model. The model was developed by the Air Force for the purpose of predicting air pollutant concentrations in the vicinities of airports. The results and recommendations do not represent Air Force policy but can be used by base personnel to estimate the impact of aircraft operations on local air quality.

This report has been reviewed by the Office of Information (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This report is approved for publication.

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LIST OF FIGURES

SECTION I

INTRODUCTION

The Aircraft Emissions Estimator (ACEE) is a screening methodology to indicate any significant air quality impact from US Air Force aircraft. This report contains all the data needed to perform ACEE analyses. Annual and maximum one-hour base aircraft operations are the only input data required for an ACEE analysis. The analysis will estimate annual emissions and one-hour maximum runway centerline ground pollution concentrations resulting from base aircraft operations. The report contains guidelines so that base environmental personnel can interpret the ACEE results. If ACEE indicates a possible air pollution problem, a more detailed base air quality analysis (e.g., Air Quality Assessment Model) may have to be performed.

The ACEE air quality analysis is not site specific. The analysis can be performed by base level personnel at any Air Force base. ACEE will allow preliminary air quality impact analysis of beddowns and mission changes at the base level. If an aircraft air pollution problem is indicated by ACEE, the base should request assistance in performing a more detailed base air pollution analysis. By screening aircraft air quality impacts at the base level, Air Force manpower and resources can be more effectively used.

SECTION II

BACKGROUND

The preliminary assessment of Air Force aircraft impact on the air quality is usually performed at the base level. This analysis is most likely an update of the aircraft emissions inventory. A great deal of time and effort is expended searching for the most current aircraft emissions factors. When total aircraft emissions are computed, they are compared with the total base emissions inventory. A crude air quality analysis might be performed using a "Q" or box dispersion model. The results of such models are inaccurate and very conservative.

The base environmental personnel are usually required to make quick impact analysis of the direct aircraft impact on air quality. Since aircraft are the only sources being investigated, a complex analysis of all base emission sources (i.e., AQAM) is not required. In addition, the base does not have the resources to spend on complex dispersion evaluations. The base personnel only need the annual aircraft emissions and "worst" case downfield pollution concentrations to estimate the impact of aircraft on air quality. This estimate gives base personnel a indication of a possible air pollution problem. If the estimate indicates a possible problem, a more detailed air quality analysis will be required.

The base level personnel require an analytical method to determine emissions from aircraft and the impact of these emissions on air quality. The procedure must contain all the data required to make aircraft emission and air quality impact analysis. The analysis must require only minimal data to eliminate the wasted man-hours. The procedure will give guidelines to interpret the results with respect to Federal, state and local standards. ACEE was developed for these reasons.

SECTION III

USAF AIRCRAFT EMISSIONS

1.0 ENGINE EMISSION MEASUREMENTS

Accurate emission data are required for analysis of the air pollution emissions from aircraft engines. For this reason the Air Force conducted a three-year engine emission survey from 1975 through 1977 (Reference 1). The most common Air Force engines were sampled using advance turbine engine emission measurement techniques. These emissions data are the most current and accurate available.

Table 1 contains emission indices for the most common Air Force aircraft engines. Careful attention should be given to the references from which the emissions data were obtained. The Scott Environmental Technology emissions measurement data are accurate to ±15 percent of the reported data (Reference 1). All other emissions data are extracted from other reports; no specific accuracy limits can be assigned to these emissions indices.

Almost all carbon monoxide (CO), total hydrocarbon (C_xH_y) and oxides of nitrogen (NO_x) emissions were measured using procedures described in the Society of Automotive Engineers Aerospace Recommended Practice 1265. The particulate (PM) emissions were derived from SAE Smoke Numbers (SNs). The SNs were converted to mass per unit volume (Reference 2). The particulates mass rates in Table 1 were calculated using the mass per unit volume results, engine operating characteristics and mass balance. Sulfur emissions were calculated assuming complete oxidation of fuel sulfur to sulfur dioxide and the average percentage of sulfur in the fuel (Reference 3).

Afterburning engines in Table 1 (except the J-85) use extrapolated data based on J-79 afterburner emissions data and the actual engine AB fuel flow rates (Reference 4).

2.0 ENGINE EMISSIONS FACTORS

The aircraft emissions factors in Table 1 are expressed in units of pollutant mass per 1000 mass units of fuel consumed, e.g., pounds per thousand pounds or grams per kilograms (Figure 1). The emissions factors and fuel flows are given for each engine mode. The engine thrust modes listed are the primary modes used by an aircraft during Landing and Takeoff (LTO) and Touch and Go (TGO) cycles.

Emissions can be calculated for any engine mode using the aircraft emission indices in Table 1. Engine Mode (EGM), Time in Mode (TIMOD) and Number of Engines (NOEG) are the only parameters required to calculate emissions. The Engine Mode Fuel Flow (FLFLW) and Emission Factor (EMFAC) are obtained from Table 1. The engine modal emissions are calculated by Equation 1.

TABLE 1. USAF AIRCRAFT ENGINE EMISSION FACTORS

ENGINE (AIRCRAFT)	ENGINE MODE	FUEL FLOW		POLLUTANT EMISSION RATE (g/kq fuel or lbs/1000 lbs fuel)*			
		kq/s	1000 lbs/hr	CARBON MONOXIDE	UNBURNED HYDROCARBONS	OXIDIES OF NITROGEN	TOTAL PARTICULATES[1]
F-100-P-100	IDLE[1]	0.179[1]	1.417[1]	24.0[1]	3.2[1]	3.3[1]	0.12[1,2]
(F-15)	APPROACH[3]	0.378[4]	3.000[4]	5.8[3]	1.9[3]	6.7[3]	0.27[2,3]
(F-16)	APPROACH[3]	0.378[4]	3.000[4]	5.8[3]	1.9[3]	6.7[3]	0.27[2,3]
	INTERMED[1]	0.643[1]	5.106[1]	1.6[1]	0.1[1]	9.8[1]	0.47[1,2]
	MILITARY[1]	1.301[1]	10.325[1]	0.9[1]	0.1[1]	27.0[1]	0.34[1,2]
	AB[5]	5.797[5]	46.010[5]	4.0[6]	0.01[6]	3.1[6]	0.15[6]
JT8D-17	IDLE[7]	0.145[7]	1.150[7]	34.0[7]	8.8[7]	3.4[7]	0.31[7]
(C-9)	APPROACH[3]	0.354[7]	2.810[7]	7.2[7]	0.5[7]	6.9[7]	0.53[7]
	INTERMED[7]	0.997[7]	7.910[7]	1.0[7]	0.05[7]	15.6[7]	0.33[7]
	MILITARY[7]	1.2[illegible][7]	9.980[7]	0.7[7]	0.05[7]	20.3[7]	0.37[7]
J33-A-35	IDLE[1]	0.151[1]	1.200[1]	127.0[1]	19.5[1]	1.5[1]	0.73[1,2]
(T-33)	APPROACH[3]	0.252[8]	2.000[8]	84.6[3]	6.5[3]	1.9[3]	0.57[2,3]
	INTERMED[1]	0.598[1]	4.750[1]	49.1[1]	1.3[1]	2.7[1]	0.02[1,2]
	MILITARY[1]	0.696[1]	5.525[1]	31.3[1]	0.5[1]	3.6[1]	0.02[1,2]
J57-P-19W	IDLE[1]	0.120[1]	0.950[1]	79.0[1]	77.0[1]	2.2[1]	0.16[1,2]
(B-52 D/E)	APPROACH[3]	0.425[9]	3.375[9]	7.9[3]	1.4[3]	5.8[3]	0.93[2,3]
	INTERMED[1]	0.819[1]	6.504[1]	2.4[1]	0.2[1]	9.5[1]	1.92[1,2]
	MILITARY[1]	0.941[1]	7.469[1]	1.9[1]	0.1[1]	11.0[1]	1.72[1,2]
	WATER AUG[10]	1.529[10]	12.133[10]	21.1[10]	2.2[10]	2.7[10]	1.89[10]
J57-P-21B	IDLE[1]	0.134[1]	1.063[1]	72.0[1]	69.0[1]	2.3[1]	0.16[1,2]
(F-100)	APPROACH[3]	0.315[11]	2.500[11]	15.7[3]	4.2[3]	4.3[3]	0.72[2,3]
(F-101)	APPROACH[3]	0.315[11]	2.500[11]	15.7[3]	4.2[3]	4.3[3]	0.72[2,3]
(F-102)	APPROACH[3]	0.315[11]	2.500[11]	15.7[3]	4.2[3]	4.3[3]	0.72[2,3]
	INTERMED[1]	0.795[1]	6.307[1]	3.2[1]	0.3[1]	8.3[1]	2.2[1,2]
	MILITARY[1]	0.969[1]	7.693[1]	2.0[1]	0.1[1]	9.8[1]	2.0[1,2]
	AB[6]	4.549[1]	36.100[1]	4.0[6]	0.01[6]	3.1[6]	0.15[6]
J57-P-43, 43WB	IDLE[1]	0.124[1]	0.986[1]	78.0[1]	75.0[1]	2.2[1]	0.14[1,2]
(C-135A, KC-135A)	APPROACH[3]	0.233[11]	1.850[11]	9.7[3]	1.8[3]	5.3[3]	0.52[2,3]
(B-52F/G)	APPROACH[3]	0.233[9]	1.849[9]	24.0[3]	9.2[3]	3.6[3]	0.293[2,3]
	INTERMED[1]	0.843[1]	6.689[1]	2.3[1]	0.1[1]	9.9[1]	1.23[1,2]
	MILITARY[1]	0.980[1]	7.779[1]	1.5[1]	0.1[1]	11.0[1]	1.74[1,2]
	WATER AUG[10]	1.529[10]	12.133[10]	21.1[10]	2.2[10]	2.7[10]	22.5[2,10]
J57-P-59W	IDLE[10]	0.157[10]	1.250[10]	65.0[10]	52.9[10]	2.4[10]	0.13[2,10]
(KC-135A)	APPROACH[3]	0.233[11]	1.850[11]	32.5[2]	14.2[2]	3.3[2]	0.22[3,10]
	INTERMED[10]	0.487[10]	3.867[10]	8.9[10]	1.1[10]	6.1[10]	0.60[2,10]
	MILITARY[10]	0.995[10]	7.900[10]	2.4[10]	0.2[10]	11.3[10]	0.84[2,10]
	WATER AUG[10]	1.529[10]	12.133[10]	21.1[10]	2.2[10]	2.7[10]	22.5[2,10]
J60-P-5B; P3	IDLE[1]	0.058[1]	0.463[1]	70.0[1]	9.2[1]	1.5[1]	0.02[1,2]
(T-39)	APPROACH[3]	0.066[7]	0.520[7]	50.5[3]	5.6[3]	1.7[3]	0.02[2,3]
	INTERMED[1]	0.180[1]	1.426[1]	5.8[1]	0.2[1]	4.0[1]	0.23[1,2]
	MILITARY[1]	0.311[1]	2.467[1]	4.0[1]	0.1[1]	4.6[1]	0.17[1,2]
J69-T-25	IDLE[1]	0.029[1]	0.231[1]	129.0[1]	19.0[1]	1.5[1]	0.55[1,2]
(T-37)	APPROACH[1]	0.036[1]	0.288[1]	106.9[1]	11.1[1]	1.7[1]	0.28[1,2]
	INTERMED[1]	0.088[1]	0.698[1]	50.0[1]	1.3[1]	2.7[1]	0.02[1,2]
	MILITARY[1]	0.138[1]	1.095[1]	32.0[1]	0.5[1]	3.6[1]	0.02[1,2]
J75-P-17	IDLE[1]	0.196[1]	1.552[1]	86.0[1]	72.0[1]	2.3[1]	0.23[1,2]
(F-106A)	APPROACH[3]	0.441[11]	3.500[11]	17.5[3]	5.2[3]	4.3[3]	0.44[2,3]
	MILITARY[1]	1.631[1]	12.943[1]	1.3[1]	0.1[1]	12.0[1]	1.08[1,2]
	AB[6]	6.766[1]	53.700[1]	4.0[6]	0.01[6]	3.1[6]	0.15[6]
J75-P-19W	IDLE[1]	0.200[1]	1.584[1]	62.0[1]	38.0[1]	2.6	0.23[1,2]
(F-105)	APPROACH[3]	0.215[11]	3.500[11]	17.5[3]	5.2[3]	4.3[3]	0.44[2,3]
	INTERMED[1]	1.089[1]	8.644[1]	1.9[1]	0.3[1]	9.0[1]	1.04[1,2]
	MILITARY[1]	1.714[1]	13.604[1]	1.5[1]	0.3[1]	10.0[1]	1.04[1,2]
	AB[6]	4.537[1]	36.010[1]	4.0[6]	0.01[6]	3.1[6]	0.15[6]

TABLE 1. USAF AIRCRAFT ENGINE EMISSION FACTORS (Continued)

ENGINE (AIRCRAFT)	ENGINE MODE	FUEL FLOW kg/s	FUEL FLOW 1000 lbs/hr	POLLUTANT EMISSION RATE (g/kg fuel or lbs/1000 lbs fuel)* CARBON MONOXIDE	UNBURNED HYDROCARBONS	OXIDIES OF NITROGEN	TOTAL PARTICULATES[1]
J79-GE-15	IDLE[1]	0.142[1]	1.130[1]	57.0[1]	12.0[1]	2.5[1]	0.5[1,2]
(F-4 C-D)	APPROACH[3]	0.441[4]	3.500[4]	9.4[3]	1.1[3]	4.8[3]	1.8[2,3]
	INTERMED[1]	0.675[1]	5.355[1]	4.6[1]	0.3[1]	5.6[1]	2.8[1,2]
	MILITARY[1]	1.125[1]	8.929[1]	2.2[1]	0.2[1]	8.9[1]	2.2[1,2]
	AB[7]	4.062[1]	32.24[1]	4.0[6]	0.01[6]	3.1[6]	0.15[6]
J79-GE-17	IDLE[12]	0.134[12]	1.060[12]	66.0[12]	23.1[12]	2.7[12]	0.18[12]
(F-4E)	APPROACH[2]	0.441[4]	3.500[4]	15.4[12]	0.5[12]	4.5[12]	0.51[12]
	INTERMED[12]	0.882[12]	7.000[12]	7.8[12]	0.1[12]	5.8[12]	0.72[12]
	MILITARY[12]	1.237[12]	9.820[12]	5.2[12]	0.1[12]	10.6[12]	0.92[12]
	AB[6]	4.404[6]	34.950[6]	4.0[6]	0.01[6]	3.1[6]	0.15[6]
J85-GE-5	IDLE[1]	0.057[1]	0.453[1]	178.0[1]	30.0[1]	1.3[1]	0.003[1,2]
(F-5)	APPROACH[1]	0.126[4]	1.000[4]	73.6[3]	6.4[3]	1.8[3]	0.007[2,3]
(T-38)	APPROACH[3]	0.184[8]	1.462[8]	43.0[3]	3.5[3]	2.3[3]	0.011[2,3]
	INTERMED[1]	0.284[1]	1.463[1]	43.0[1]	3.5[1]	2.3[1]	0.011[1]
	MILITARY[1]	0.331[1]	2.630[1]	29.0[1]	0.8[1]	2.6[1]	0.018[1]
	AB[6]	1.049[1]	8.323[1]	26.0[6]	0.07[6]	2.0[6]	0.008[6]
R-3350	IDLE[12]	0.013[12]	0.107[12]	743.0[12]	191.0[12]	1.0[12]	60.0[12]
(C-119)(C-121)	INTERMED[12]	0.077[12]	0.610[12]	692.0[12]	9.5[12]	9.4[12]	40.0[11]
	MILITARY[12]	0.118[12]	0.936[12]	1160.0[12]	20.4[12]	11.1[12]	20.0[12]
R-4360	IDLE[12]	0.018[12]	0.140[12]	743.0[12]	191.0[2]	1.0[12]	60.0[12]
(C-97)	INTERMED[12]	0.100[12]	0.794[12]	692.0[12]	9.5[12]	9.4[12]	40.0[12]
	MILITARY[12]	0.153[12]	1.218[12]	1160.0[12]	20.4[12]	11.1[12]	20.0[12]
TF30-P-3	IDLE[1]	0.107[1]	0.850[1]	72.0[1]	62.0[1]	2.3[1]	0.01[1,2]
(F-111A/E)	APPROACH[3]	0.265[4]	2.100[4]	9.2[3]	2.1[3]	4.8[1]	0.05[1,2]
	INTERMED[1]	0.621[1]	4.926	1.3[1]	0.1[1]	9.4[3]	0.45[2,3]
	MILITARY[1]	0.775[1]	6.148[1]	0.8[1]	0.03[1]	12.0[1]	0.40[1,2]
	AB[6]	4.838[1]	38.400[1]	4.06[6]	0.01[6]	3.1[6]	0.15[6]
TF30-P-7	IDLE[1]	0.119[1]	0.948[1]	53.0[1]	30.0[1]	3.0[1]	0.02[1,2]
FB-111A	APPROACH[3]	0.265[4]	2.100[4]	11.5[3]	3.2[3]	6.1[3]	0.12[1,2]
	INTERMED[1]	0.719[4]	5.706[1]	1.2[1]	0.2[1]	14.0[1]	0.44[1,2]
	MILITARY[1]	0.914[1]	7.258[1]	0.8[1]	0.1[1]	20.0[1]	0.35[1,2]
	AB[6]	4.838[4]	38.400[1]	4.0[6]	0.01[6]	3.1[6]	0.15[6]
TF 30-100	IDLE[1]	0.119[1]	0.948[1]	48.0[1]	19.0[1]	2.9[1]	0.02[1,2]
(F-111F)	APPROACH[3]	0.265[4]	2.100[4]	9.9[3]	2.7[3]	6.3[3]	0.08[2,3]
	INTERMED[1]	0.903[1]	7.164[1]	0.7[1]	0.1[1]	20.0[1]	0.32[1,2]
	MILITARY[1]	1.144[1]	9.077[1]	0.7[1]	0.1[1]	28.0[1]	0.24[1,2]
	AFTERBURNER[6]	6.804[1]	54.000[1]	4.0[6]	0.01[6]	3.1[6]	0.15[6]
TF33-P-3	IDLE[1]	0.113[1]	0.900[1]	107.0[1]	84.0[1]	1.8[1]	0.23[1,2]
(B-52H)	APPROACH[9]	0.478[9]	3.797[3]	6.3[3]	2.6[3]	5.8[3]	0.99[2,3]
	INTERMED[1]	0.786[1]	6.236[1]	2.3[1]	0.7[1]	8.5[1]	1.88[1]
	MILITARY[1]	0.937[1]	7.436[1]	1.7	0.6[1]	10.0[1]	1.73[1]
TF33-P-7	IDLE[1]	0.134[1]	1.067[1]	93.0[1]	77.0[1]	1.8[1]	0.11[1,2]
(C-141)	APPROACH[3]	0.315[7]	2.500[7]	13.7[7]	3.6[7]	3.8[7]	0.39[7]
	INTERMED[1]	0.911[1]	7.230[1]	1.3[1]	0.1[1]	9.4[1]	1.30[1,2]
	MILITARY[1]	1.098[1]	8.711[1]	0.8[1]	0.03[1]	12.0[1]	0.91[1,2]
TF34-GE-2	IDLE[1]	0.049[1]	0.390[1]	106.0[1]	32.0[1]	2.0[1]	0.04[1,2]
(A-10)	APPROACH[3]	0.157[4]	1.250[4]	8.3[3]	0.6[3]	5.8[3]	0.02[2,3]
	INTERMED[1]	0.186[1]	1.473[1]	4.3[1]	0.2[1]	7.5[1]	0.01[1,2]
	MILITARY[1]	0.323[1]	2.562[1]	2.3[1]	0.1[1]	10.0[1]	0.05[1,2]
TF39-GE-1	IDLE[1]	0.143[1]	1.133[1]	67.0[1]	23.0[1]	3.0[1]	0.015[1,2]
(C-5A)	APPROACH[3]	0.189[7]	1.500[7]	39.2[3]	13.2[3]	3.9[3]	0.016[2,3]
	INTERMED[1]	1.515[1]	12.025	0.7[1]	0.2[1]	28.0[1]	0.030[1,2]
	MILITARY[1]	1.599[1]	12.687[1]	0.7[1]	0.2[1]	28.0[1]	0.025[1,2]

TABLE 1. USAF AIRCRAFT ENGINE EMISSION FACTORS (Continued)

ENGINE (AIRCRAFT)	ENGINE MODE	FUEL FLOW kg/s	FUEL FLOW 1000 lbs/hr	POLLUTANT EMISSION RATE (g/kg fuel or lbs/1000 lbs fuel)* CARBON MONOXIDE	UNBURNED HYDROCARBONS	OXIDIES OF NITROGEN	TOTAL PARTICULATES[1]
TF41-A-1	IDLE[1]	0.127[1]	1.009[1]	119.0[1]	92.0[1]	1.5[1]	0.15[1,2]
(A-7D)	APPROACH[3]	0.441[4]	3.500[4]	10.2[3]	2.2[3]	6.8[3]	0.36[2,3]
	INTERMED[1]	0.735[1]	5.831	3.7[1]	0.4[1]	12.0[1]	0.52[1,2]
	MILITARY[1]	1.061[1]	8.419[1]	1.8[1]	0.2[1]	21.0[1]	0.67[1,2]
T56-A-7	IDLE[1]	0.091[1]	0.725[1]	32.0[1]	21.0[1]	3.9[1]	0.83[1,2]
(C-130A-F)	APPROACH[3]	0.104[7]	0.827[7]	22.2[3]	12.4[3]	4.4[3]	0.97[2,3]
	INTERMED[1]	0.233[1]	1.848[1]	2.4[1]	0.5[1]	9.2[1]	0.51[1,2]
	MILITARY[1]	0.248[1]	1.965[1]	2.[illegible][1]	0.4[1]	9.3[1]	0.50[1,2]
T76-G-10	IDLE[12]	0.031[12]	0.250[12]	23.8[12]	7.4[12]	7.4[12]	0.38[12]
(OV-10)	APPROACH[12]	0.057[4]	0.450[4]	17.2[12]	0.8[12]	8.5[12]	0.50[12]
	INTERMED[12]	0.101[12]	0.800[12]	5.9[12]	0.1[12]	9.9[12]	0.63[12]
	MILITARY[12]	0.113[12]	0.900[12]	2.3[12]	0.06[12]	10.3[12]	0.71[12]
IO-360	IDLE[13]	0.004[13]	0.030[13]	848.0[13]	145.0[13]	1.1[13]	60.0[13]
(O-2)	APPROACH[13]	0.008[13]	0.062[13]	945.9[13]	23.6[13]	5.5[13]	40.9[13]
(T-41)	APPROACH[13]	0.005[8]	0.040[8]	879.0[13]	70.6[13]	2.5[13]	55.0[3,13]
	INTERMED[13]	0.009[13]	0.070[13]	972.0[13]	17.4[13]	6.6[13]	40.0[13]
	MILITARY[13]	0.011	0.090[13]	1030.0[13]	22.5[13]	5.3[13]	20.0[13]
O-470	IDLE[13]	0.002[13]	0.015[13]	743.0[13]	191.0[13]	1.1[13]	60.0[13]
(O-1)	APPROACH[13]	0.008[13]	0.061[13]	713.2[13]	17.1[13]	1.0[13]	45.5[13]
	INTERMED[13]	0.011[13]	0.086[13]	697.0[13]	9.5[13]	1.0[13]	40.0[13]
	MILITARY[13]	0.017[13]	0.131[13]	1,160.0[13]	20.4[13]	9.4[13]	20.0[13]

*Average sulfur emissions are 1.0g/kg fuel for turbine engines using JP-4 fuel and 0.6g/kg fuel for piston engines using "aviation gasoline".

1. Souza, A. F. and Daley, P. S., USAF Turbine Engine Emission Survey, CEEDO-TR-78-34, September 1978.

2. Particulate mass flow rate calculations.

3. Approach engine emissions were calculated by a power curve interpolation method using engine mode fuel flows and emissions indices.

4. Mahler, Lt Col, HQ TAC/DOV, trip report containing approach aircraft fuel flows by Lt P. D. Music (Det 1 ADTC) dated 15 August 1977.

5. Souza, A. F., F-100 Afterburner Turbine Engine Emission Test Report, CEEDO-TR-78-54, September 1978.

6. "Development of Emissions Measurement Techniques for Afterburning Turbine Engines", AFAPL-TR-75-52, October 1975. All engine's afterburner emissions (except for the J-85 engine) use the J79-G15 reactive plume emissions indices from AFPL-TR-75-52.

7. Pace, R. G., "Technical Support Report - Aircraft Emission Factors," USEPA Office of Mobile Source Air Pollution Control, Ann Arbor, MI, March 1977.

8. Peterson, Lt Col Roy W., HQ ATC/DOV, letter report containing aircraft engine approach mode fuel flows dated 3 August 1977.

9. Hacker, Capt Kenneth, 1st GEG SAC, fuel flows for B-52 approach are given in a letter dated 21 December 1976.

10. Souza, A. F. and Scott, H. A., J57-59W Engine Emission Test Report, CEEDO-TR-78-37, September 1978.

11. Personal telephone communications from Lt David Van Gasbeck (NGB/DEM) to Lt John Hunt (Det 1 ADTC) on 2 August 1977 giving ANG's aircraft engine approach fuel flows.

12. "Aircraft Engine Emission Catalog", AESO 101-74-1, NARF, North Island CA March 1974.

13. Bogdan, Leonard and McAdams, H.T.: Analysis of Exhaust Emission Measurements, CAL Report No. NA-5007-K-1, October 15, 1971.

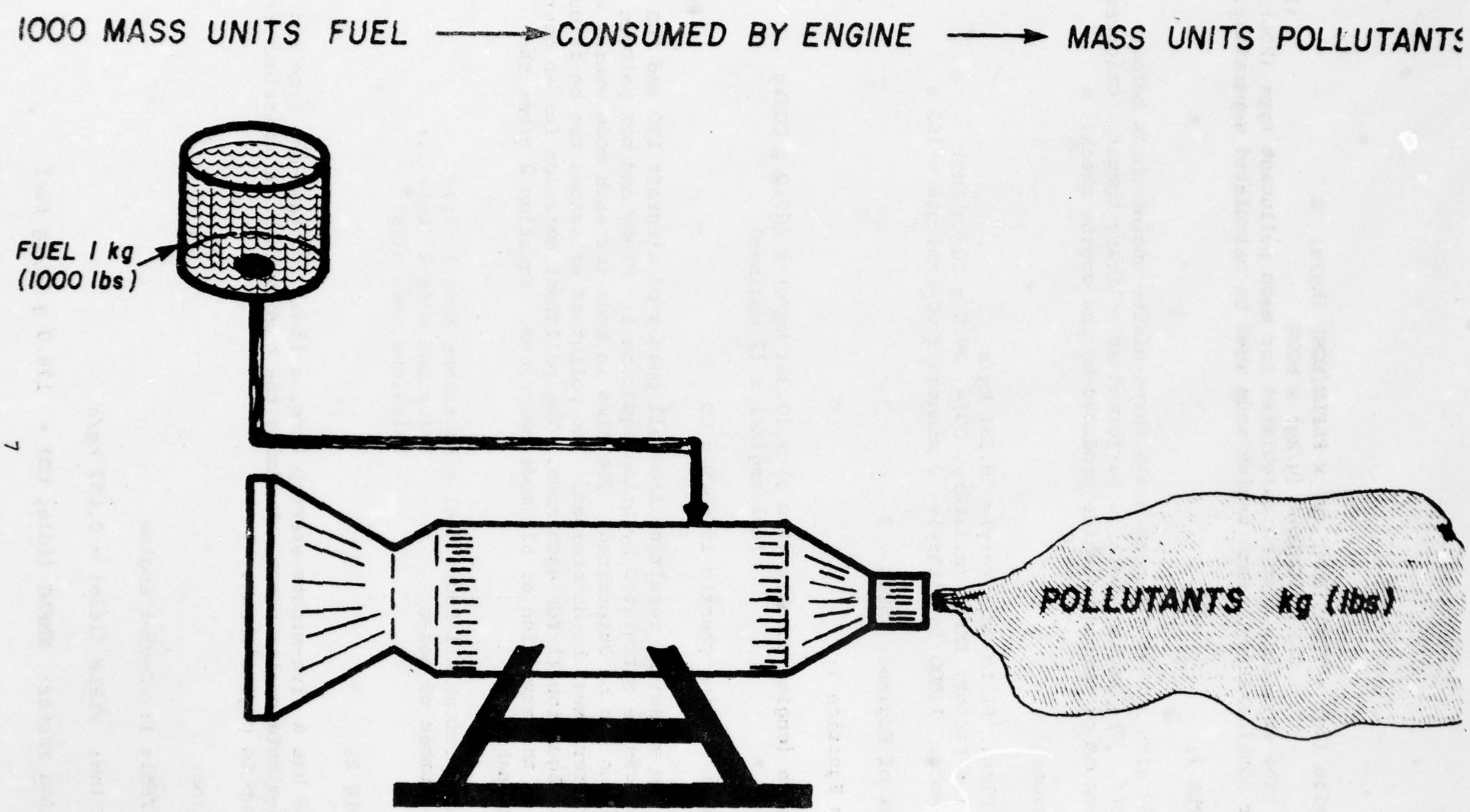

Figure 1. Emission Factor.

Emission (kg) = TIMOD(EGM) (s) x FLFLW(EGM) (kg/s) x
EMFAC(EGMPOL) (g/kg) x NOEG (1)

The emissions must be calculated for each pollutant type (POL) under consideration. Each engine mode must be calculated separately.

EXAMPLE 1:

A T-38 with a J-85-5 engine has a three-minute engine check before takeoff. The engine check is performed at military thrust. Calculate the amount of carbon monoxide produced by the engine check.

Solution:

Fuel Flow: FLFLW (military)= 0.331 kg/s
Emission Factor: EMFAC (military, CO)= 29.0 g CO/kg fuel
Time Mode: TIMOD (military)= 3 minutes x 60 s/minute = 180 s

Number of Engines: NOEG = 2

Using Equation 1:

Emission (engine check)= (180 s) x (0.331 kg/s) x (29.0 g CO/kg fuel/engine) x (2 engines)

Emission (engine check)= 10366.9 g CO

The emissions resulting from all phases of aircraft LTO and TGO cycles can be calculated by using Equation 1. Flyby and box pattern emissions can be determined. The time in mode for each mode making up the pattern must be determined. The pollutant emissions can be calculated (Equation 1) for each mode. The pollutant emission for an operation is the summation of all mode emissions. Equation 2 gives the relationship.

Total Emissions All Modes (kg) = Emissions Mode 1 (kg)+ Emissions Mode 2 (kg)+...+ Emissions Mode n(kg) (2)
n = number of modes

EXAMPLE 2:

A T-38 has a five-minute startup time, a 15-minute taxi-out time and three-minute engine check. Estimate the carbon monoxide emissions from startup to engine check.

Solution:

From Table 1: J-85-5 engine

Fuel Flow: FLFLW (idle) = 0.057 kg/s

Emission Factor: EMFAC (idle, CO) = 178.0 g CO/kg fuel

Total Idle Time: TIMOD (idle) = Engine Startup(s) + Taxi-Out(s)
= (5 minutes + 15 minutes) x 60 s/minute
= 1,200 s

Using Equation 1:

Emission (Startup-Taxi) = (1,200 s) x (0.57 g/s) x (178.0 g CO/kg fuel) x (2 engines)

Emissions (Startup-Taxi) = 24,350.4 g CO

From Example 1:

Emissions (Engine Check) = 10,366.9 g CO

Using Equation 2:

Emissions (Startup-Engine Check) = 24,350.4 g CO + 10,366.9 g CO

Emissions (Startup-Engine Check) = 34,717.30 g CO

The emissions are calculated in a multiplicative relation. Therefore, accurate time in mode data is required. Doubling the time in mode can double the amount of emissions.

The times in mode during each phase of the LTO and TGO cycles can be obtained by direct observation or pilot interviews. The direct observation consists of going out to the flight line and timing the aircraft. The time spent in each phase of the LTO or TGO cycle is recorded. LTO and TGO time in mode data should be collected for each aircraft. The best observation point is the tower. As many aircraft as possible should be timed during peak operational periods. An average of the time phase should be used as the time spent in that phase. Pilot interviews are less time consuming but much less accurate.

3.0 LTO AND TGO EMISSIONS

Calculations of the pollutant emissions for each phase of the LTO and TGO cycle are time consuming. To eliminate these calculations, the AQAM Source Inventory was employed (Reference 5). The AQAM Source Inventory uses the emissions indices and aircraft operational data (e.g., climb angle, approach speed) to calculate the amount of pollutants during each phase of the LTO cycle. The same procedures described in 2.0 are used by the AQAM Source Inventory to calculate total LTO and TGO aircraft emissions. Pollutant emissions per individual LTO phase and total emissions are outputs of AQAM Source Inventory. The standard AQAM LTO cycle is illustrated in Figure 2. The TGO cycle omits Phases 1-4 and 7-9. The runway roll speeds and distances are modified for the TGO faster approaches. All emissions are calculated to and from 0.914 km above ground level.

The AQAM Source Inventory calculates runway roll distances using meteorological conditions and pressure altitude. The parameters used for ACEE are listed in Table 2. The conditions are based on an annual average of 12 Air Force bases in the continental US and represent a cross section of US Air Force bases.

The taxi-out and taxi-in distances are assumed to be 4.0 km for both incoming and departing flights. The taxi distance was determined from an Air Force-wide average of taxi distances (Reference 6). The average time in the taxi phase varies with aircraft taxi speeds and operational procedures. Modifications to these taxi times and other LTO and TGO phases is discussed in 4.0.

The AQAM generated LTO and TGO pollutant emissions are presented in Appendix A. The aircraft emissions are listed in alphanumeric order by model designation. The emissions for each of the five pollutant types are given for the individual LTO phases. The total LTO pollutant emission is the sum of the individual phases. The TGO cycle total emissions are presented and are calculated separately from the LTO emissions.

The emissions emitted during an LTO cycle can be found by locating the aircraft model in Appendix A. The emissions are expressed in metric tons per cycle.

EXAMPLE 3:

Find the amount of NO_x emitted by a T-38 during a standard LTO cycle.

Locate the T-38 LTO and TGO emissions in Table A-26.

Emissions (NO_x) = 6.0 E-04 metric tons x 103 kg/metric ton = 0.6 kg/LTO

The "E" exponential notation is explained in Appendix B. The conversion factors from metric tons to other units are also described in Appendix A.

4.0 LTO MODIFICATIONS

The LTO cycle emissions can be modified to simulate special cases (e.g., arming, queuing). The engine thrust mode and time in mode for each special case are required. Using Equation 1, the emissions can be calculated for each engine mode and pollutant. These special case emissions can be added to the final LTO pollutant total. The result is the LTO pollutant emissions including the special cases.

EXAMPLE 4:

At training base X, a 10-minute queue develops at the beginning of the runway because of the heavy aircraft traffic. What effect does the queue have on LTO CO emissions?

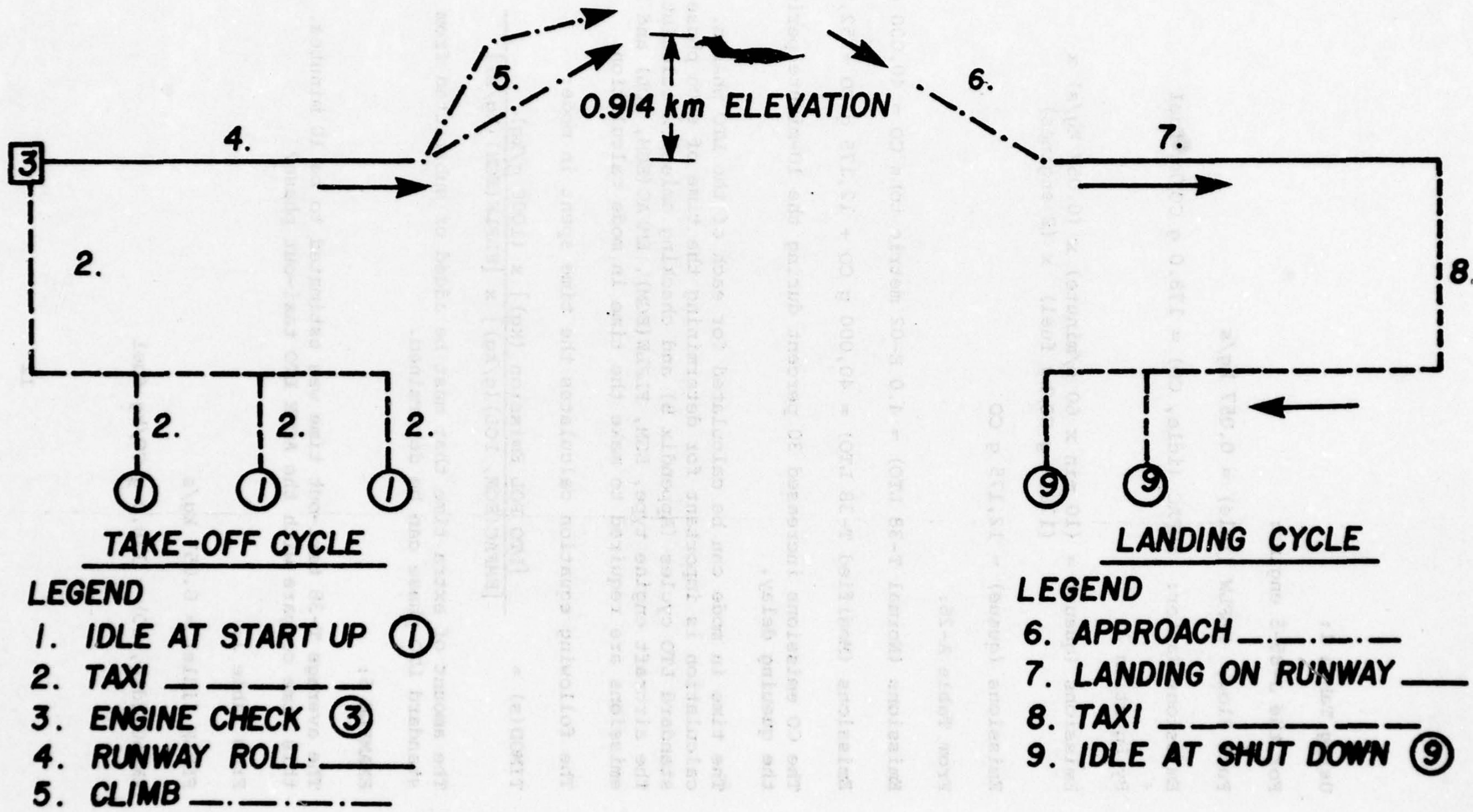

Figure 2. **LANDING AND TAKEOFF CYCLE**

Using Table 1:

For the J-85-5 engine:

Fuel Flow: FLFLW (idle) = 0.057 kg/s

Emissions Factor: EMFAC (idle, CO) = 178.0 g CO/kg fuel

By Equation 1:

Emissions (queue) = (10 min x 60 s/minute) x (0.057 kg/s) x (178.0 g CO/kg fuel) x (2 engines)

Emissions (queue) = 12,175 g CO

From Table A-26:

Emissions (Normal T-38 LTO) = 4.0 E-02 metric tons CO = 40,000 g

Emissions (Modified T-38 LTO) = 40,000 g CO + 12,175 g CO = 52,175 g CO

The CO emissions increased 30 percent during the 10-minute period due to the queuing delay.

The time in mode can be calculated for each of the LTO phases. This calculation is important for determining the time of each phase of the standard LTO cycles (Appendix B) and checking emission calculations. The aircraft engine type, EGM, FLFLW(EGM), EMFAC(EGM, POL) and LTO phase emissions are required to make the time in mode calculation.

The following equation calculates the time spent in mode:

$$\text{TIMOD(s)} = \frac{[\text{LTO POL Emission (kg)}] \times (1000\ \text{g/kg})}{[\text{EMFAC(EGM, POL)(g/kg)}] \times [\text{FLFLW(EGM)(kg/s)}]}$$

The amount of extra time that must be added or subtracted from the standard LTO phase can be determined.

EXAMPLE 5:

The average T-38 taxi-out time was estimated to be 10 minutes. Does this time compare with the ACEE LTO taxi-out phase?

From Table 1:

FLFLW (idle) = 0.057 kg/s

EMFAC(idle, CO) = 178.0 g CO/kg fuel

From Table A-26: LTO Emissions (Taxi-Out, CO) = 1.31 XE-02 metric tons CO x = 13,100 g CO

Time: TIMODF = [(13.1 kg CO) x (1000 g/kg)] ÷ [(0.057 kg/s fuel) x (178.0 g CO/kg fuel) x (2 engines)]

Time (Taxi-Out) = 646 s = 10 minutes 45 s

The 10-minute observed time and predicted 10-minute 45 second LTO taxi-out time are similar. The normal LTO cycle taxi-out emission can be used.

All special modifications to the LTO and TGO emissions (Appendix A) will result in more accurate results. For quick estimates, the LTO and TGO cycle emissions tabulated should be used.

5.0 ANNUAL EMISSIONS

Most emissions are expressed in terms of annual emissions. Aircraft annual emissions can be calculated using ACEE. The annual aircraft emissions calculated by ACEE can be compared with other emission sources on and around the base. The comparison can give the aircraft's contribution to the area's total emissions.

The number of annual aircraft operations is required to compute annual emissions. The aircraft data must be in the form of LTOs and TGOs per year. The data can usually be obtained from the base operations sections and are reported monthly. The aircraft types might have to be separated and data manipulation might be necessary to reduce data into yearly operations format for ACEE.

The yearly aircraft operational and the LTO and TGO emission data are required. The number of LTO operations per year is multiplied by the pollutant emissions from one LTO operation (Equation 4). The result is the annual aircraft pollutant emissions. All emissions of the same pollutant are added to obtain the total aircraft emissions.

Annual Emissions (metric tons) = LTO pollutant emissions (metric tons) x Number of Annual Aircraft LTOs and TGOs (4)

The pollution emissions changes can be calculated for operational changes (e.g., decreased engine checks times, decreased arming times) or subtracted from the modified LTO, TGO or flyby cycle.

The detail to which to modifications and special operational characteristics are addressed will depend upon the purpose of the analysis. ACEE LTO and TGO emissions can be used for quick estimates of emissions. The modified LTO and TGO cycles can be used for environmental impact statements. Section V gives the limitation of ACEE emissions, and should be examined before any application of ACEE emissions.

SECTION IV

SHORT TERM AIR QUALITY

1.0 AIR QUALITY

Air quality analysis is the most important factor in determining the impact of aircraft on the environment. Dispersion and emission analyses are the two main factors in air quality analysis. The dispersion analysis estimates the atmosphere's ability to transport and dilute pollution due to advective winds and eddies caused by atmospheric instability. Atmospheric dispersion of pollutant is independent of source emissions. The emission analysis determines the amount of pollutants released into the atmosphere.

The AQAM short term model quantifies the ambient air quality resulting from atmospheric dispersion and source emissions. It can calculate atmospheric dispersion as a function of wind speed, mixing height, atmospheric stability and distance from almost any base emission source. Gaussian dispersion models are used by AQAM to predict air quality ground level concentrations at air bases (References 7 and 8). These concentrations can be compared with US National Primary and Secondary Ambient Air Quality Standards to predict the impact on air quality. ACEE uses AQAM short term and typical meteorological conditions to predict ambient air quality resulting from aircraft operations. ACEE does not consider other base sources (i.e., power plants).

2.0 METEOROLOGICAL CONDITIONS

Meteorological conditions determine the dispersion potential of the atmosphere. Under poor atmospheric dispersion conditions, air pollution problems can exist. These poor dispersion conditions usually occur during the early morning hours. Calm wind speeds and a stable atmosphere cause very little diluting or transporting of pollutants. The lowest dispersion potential of the year is called the "worst case." The National Ambient Air Quality Standards are described in terms of annual average concentration or concentrations not to be exceeded more than once per year.

Typical "worst case" meteorological conditions were used for ACEE dispersion and air quality calculations. These conditions are presented in Appendix C and Figures 4-7. The meteorological data are annual one-hour averages from 12 US Air Force bases. The averages represent a good cross section of weather climates in the United States. The morning conditions were chosen because the greatest potential for air pollution problems occur then. The small tailwind for takeoff gives the maximum downfield pollution concentrations for the "worst case." The tailwind is not typical of normal aircraft takeoff procedures.

TABLE 2. ACEE ANNUAL METEOROLOGICAL CONDITIONS
12 AIR FORCE BASES ANNUAL AVERAGES

Meteorological Data	
Average Temperature	17.8°C (64°F)
Pressure Altitude	359.6 m (1180 ft)
Average Wind Speed*	3.8 m/s (8.5 mph)

* A headwind to the aircraft's takeoff and landing is used for AQAM Source Inventory calculations.

TABLE 3. GROUP NUMBER

Aircraft	CO	NO_x	PM	SO_x
A-7	2	3	2	2
A-10	2	2	1	2
A-37	3	2	1	2
B-52D/F	5	5	4	5
B-52G	5	4	4	5
B-52H	5	4	4	5
B-57A/E	3	2	4	2
B-57F	3	4	3	3
C-5LS	4	5	2	4
C-7	1	2	2	2
C-9	1	3	3	2
C-97	5	3	5	2
C-119	4	2	4	1
C-121	5	3	5	1
C-130A/G	3	4	4	4
C-130H	2	4	3	3
C-135B	4	4	4	5
C-141	4	4	3	4
F-4	2	3	3	3
F-4E	2	3	3	1
F-5	3	2	2	[illegible]
F-15	1	3	2	[illegible]
F-16	1	3	2	[illegible]
F-100	3	3	2	[illegible]
F-101	2	3	3	[illegible]
F-102	2	4	3	[illegible]
F-104A	3	3	3	3
F-104G	2	3	3	3
F-105	3	3	3	3
F-106	2	3	3	3
F-111A	3	4	3	4
F-111D	3	4	2	4
F-111F	3	4	2	4
KC-135A	4	4	3	4
O-1	1	1	3	1
O-2	2	1	3	1
OV-10	1	4	2	1
T-33	2	1	2	2
T-37	2	1	1	1
T-38	3	1	2	2
T-39	1	1	2	2
T-41	1	1	3	1

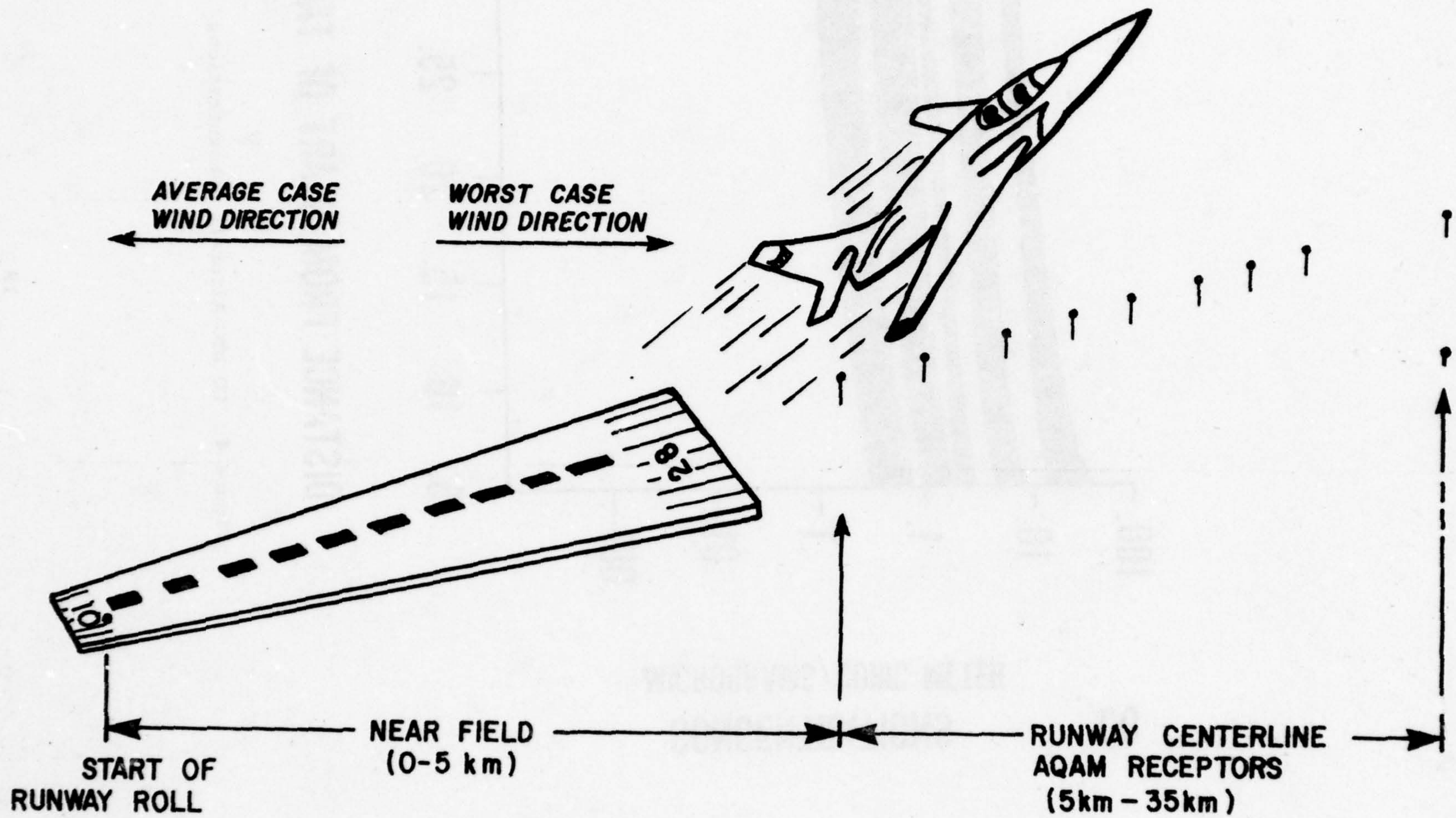

Figure 3. **RUNWAY CENTERLINE CONCENTRATIONS**

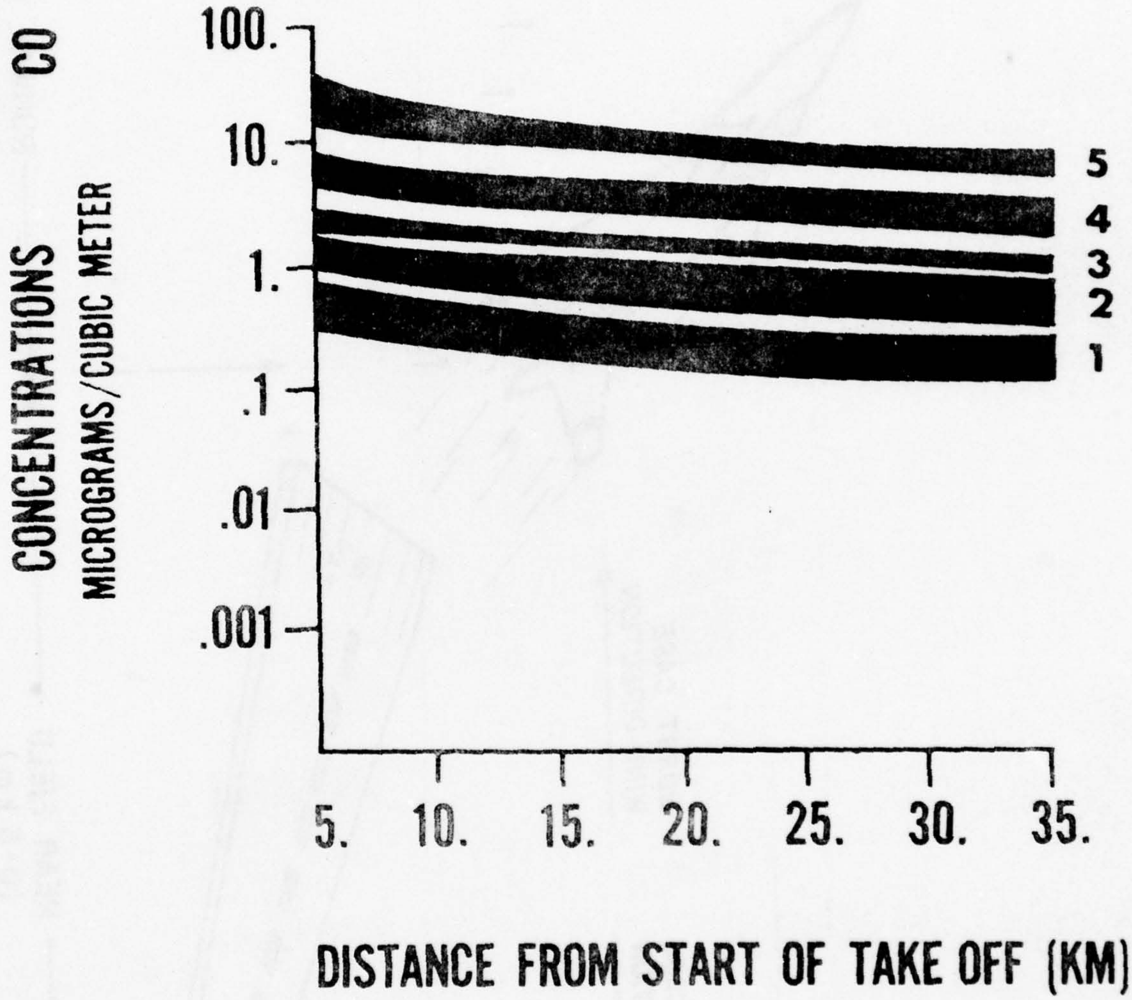

Figure 4. CO LTO Aircraft Concentrations

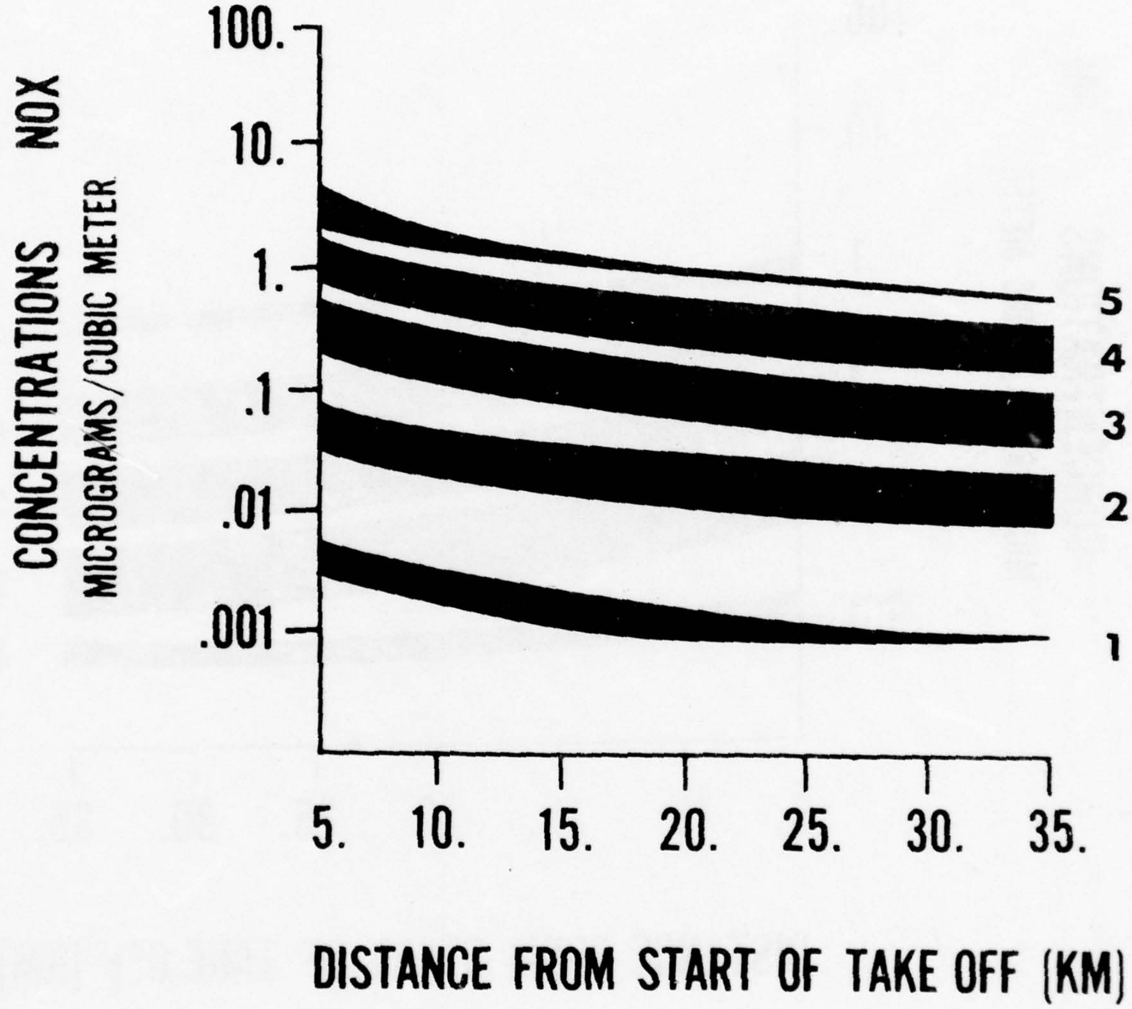

Figure 5. NO_x LTO Aircraft Concentrations

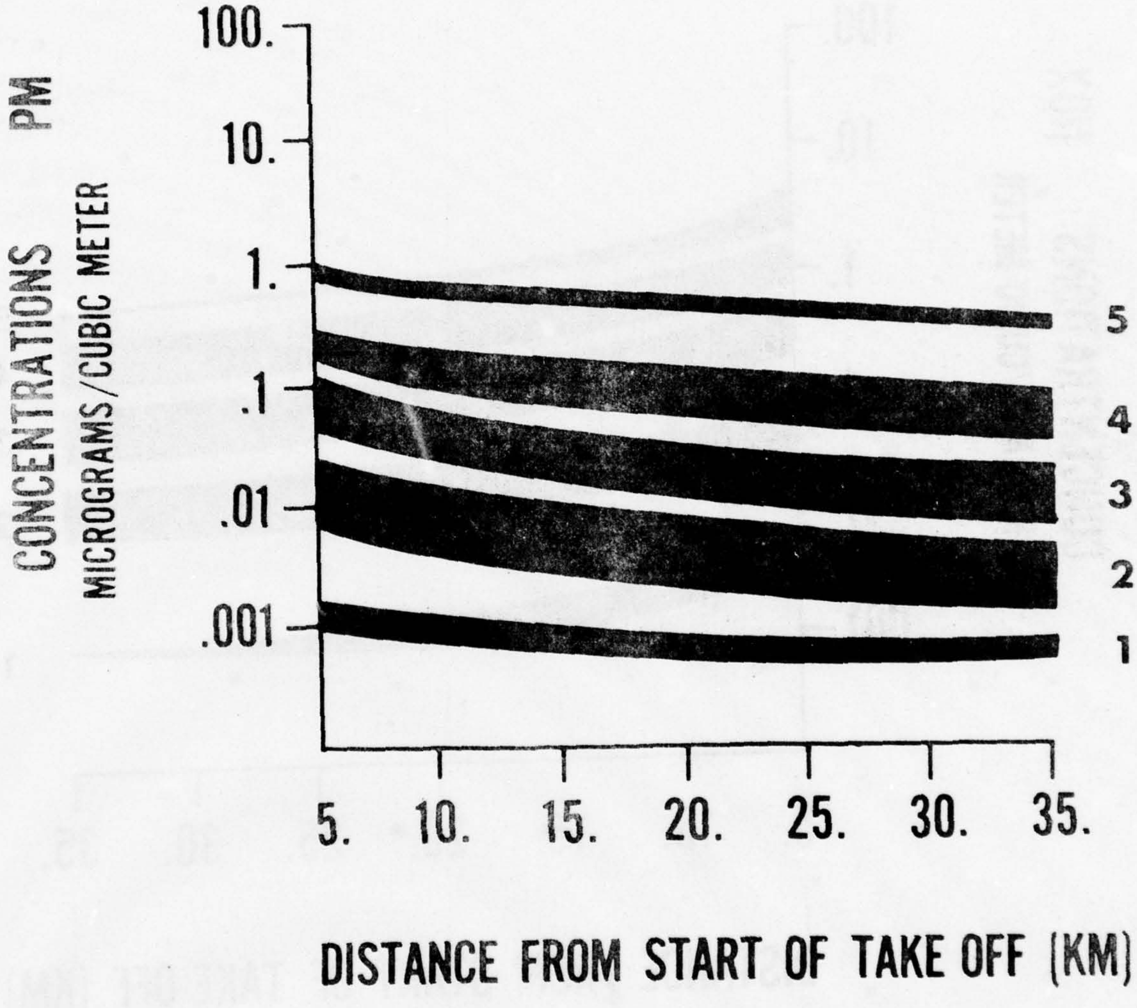

Figure 6. PM LTO Aircraft Concentrations

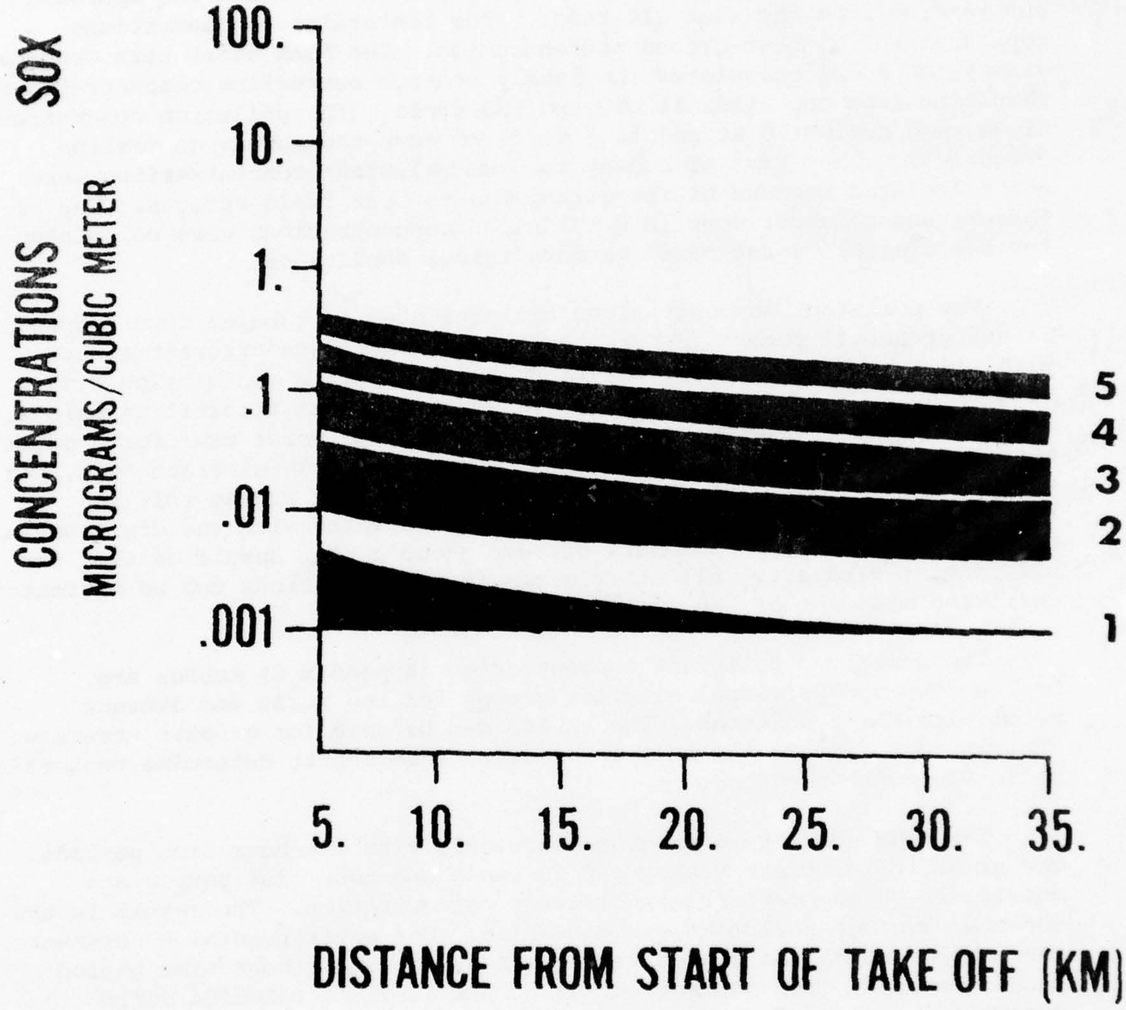

Figure 7. SO_x LTO Aircraft Concentrations

3.0 RUNWAY CENTERLINE CONCENTRATIONS

Downfield centerline pollutant concentrations were calculated for each major aircraft type, using the AQAM short term program. The AQAM short term model simulated downfield ground receptor concentrations resulting from an aircraft takeoff and climb to 914 m and its approach and landing from the same altitude. The centerline concentrations represent the highest ground concentration. The AQAM short term Gaussian dispersion model calculated the hourly average centerline concentrations resulting from one aircraft LTO and TGO cycle. The pollution concentrations were estimated at points 5 to 35 km down the runway centerline (Figure 3). The start of runway to 5 km pollutant concentrations were not calculated because of inaccuracy due to near field effects. The takeoff and climbout downfield pollution concentrations were calculated for the typical "worst case" meteorological conditions.

The pollutant concentrations are presented in tabular form (Appendix C) and graphical format (Figures 4-7). Table 3 lists aircraft groups with similar pollutant concentrations and is used in conjunction with Figures 4-7. The groups include 98.0 percent of the aircraft emissions in the group. The graphical method considers the worst case for a quick analysis of pollution concentrations. By knowing the aircraft type, the group can be found. The distance from the start of runway roll is selected and the pollutant concentration associated with the distance is determined. The upper boundary of each group's plot should be used for multiengine aircraft. All other aircraft concentrations can be estimated using the midpoint of the plot.

The downfield pollutant concentration (Appendix C) tables are broken down to individual aircraft groups for the worst and average meteorological conditions. The tables can be used for greater accuracy. The aircraft type is the only information required to determine centerline pollution concentrations.

The AQAM short term program deals only with one-hour time periods. The number of aircraft taking off during a one-hour time period are multiplied by the particular pollutant concentration. The result is the one-hour average pollutant concentration. For environmental assessments, the maximum number of planes taking off during a one-hour time period should be used. The concentrations of all aircraft takeoffs during the same time period and at the same receptor are summed for the total centerline concentration at the receptor point.

EXAMPLE 8:

Base X has a town lying on the runway centerline 20 km from the start of runway roll. What are the NO_x concentrations resulting from the following 0800-0900 recorded maximum operations?

	Departures
T-37	14
T-38	10

Using Figure 5 for a quick estimate:

T-37 NO_x Concentration at 20 km = .6 $\mu g/m^3$

T-38 NO_x Concentration at 20 km = 1.5 $\mu g/m^3$
Note: Figures 4-7 have log concentration scales.

Multiply each concentration by the number of departures:

T-37 = 0.6 mg/m^3 x 12 departures = 7.2 $\mu g/m^3$

T-38 = 1.5 mg/m^3 x 10 departures = 15.0 $\mu g/m^3$

Adding the concentrations:

Total NO_x concentrations at 20 km = 22.2 $\mu g/m^3$

Using Tables C-67 and C-68 from Appendix A:

Total NO_x concentrations at 20 km = 22.1 $\mu g/m^3$
Note: The value 0.00 indicates that the centerline concentrations are less than 0.005 mg.

The centerline concentrations calculated assume a straight climbout and represent the highest ambient pollution concentrations. Pollution concentrations will decrease rapidly from either side of the runway centerline. Special fighter climbout procedures are not simulated by the AQAM program; however, the pollution concentration would be lower than the straight climbout now being simulated by AQAM because of the steeper climbout angles used by fighters and trainers.

4.0 COMPARISON WITH STANDARDS

The pollution concentration can be compared with the National Primary Standards. ACEE concentrations represent the "worst case." These "worst case" concentrations can be directly compared to "not to exceed more than once a year" standards. A power law (Reference 9) is required to convert one-hour averages to 24- or 8-hour average concentrations.

The Pollution Standards Index (PSI) and EPA Report (Reference 10) can facilitate evaluating effects of aircraft on air quality. The PSI is based on a scale of 0 to 500 according to health effects. A PSI of 100 is the Primary National Ambient Air Quality Standard (NAAQS). A PSI of 50 is 50 percent of the Primary NAAQS. Hydrocarbons do not have PSIs because there are no known direct health effects associated with this

pollutant (Reference 10). Every pollutant can be normalized using the PSI scale. Since all the pollutants are normalized, their PSIs can be compared directly. Problem pollutants can be identified directly.

SECTION V

ACEE DATA ANALYSIS

Calculated emissions and air quality data using ACEE must be analyzed. ACEE is not a final analytical tool. It is a decision step to determine the possibility of an air quality problem resulting from aircraft. A more powerful analytical model such as AQAM must be used if ACEE detects a possible air pollution problem. It is important to remember that ACEE is a conservative screening device. Any indication of possible aircraft pollution problems will have to be examined more thoroughly. A more comprehensive air quality examination will either confirm or reject the ACEE "possibility" of an adverse impact of aircraft on the air quality.

1.0 EMISSIONS ANALYSIS

The annual aircraft emissions can be employed to make crude air quality analyses. The annual aircraft emissions can be compared with other base sources or environ sources. A survey of most major United States airports indicated that the average aircraft annual emissions did not exceed two percent of the total source emissions (Reference 11). The two percent aircraft emissions can be used as a guide if the base is located in a major urban area. However, the two percent figure is not valid for areas where the base is the only major source.

Base aircraft operations resulting in annual emissions in excess of 226,796 kg of any one pollutant per year should be investigated more closely. The EPA defines 226,796 kg annual emissions as a major source. The possibility of an aircraft related air pollution problem could exist. ACEE air quality should be examined carefully in this case. Any conclusions made concerning aircraft impacts should use the ACEE air quality data. Emissions data do not give any information about the dispersion of pollutants in the atmosphere.

2.0 SHORT TERM AIR QUALITY ANALYSIS

The downfield ambient air quality can be estimated using ACEE. The air pollution concentrations can be estimated for one-hour periods. The calculated results represent the maximum air pollution concentration from an aircraft takeoff and climbout. The results must be interpreted very carefully. The limitations are summarized in Section VI. Failure to recognize the limitations will result in poor conclusions with no value for assessment of air quality.

The downfield dispersion curves are given for CO, NO_x, PM and SO_x. The total hydrocarbon dispersion curves have not been computed because hydrocarbons do not have any health effects in themselves. For hydrocarbons the emission estimates are the most valid indicator of a significant aircraft contribution.

The Gaussian dispersion model does not predict reactive pollutants concentrations, e.g., oxidants. However, hydrocarbons are a main contributor with NO_x in forming oxidants. The downfield hydrocarbons presented in Appendix C are for future reference when hydrocarbon pollution is better understood.

The centerline concentration curves and tables (Appendix C) are based on one-hour worst case meteorological conditions. The AQAM Short Term program uses special one-hour wind averaging schemes. An attempt to predict the air quality for more than a one-hour time period is invalid without special correction factors. The curves and tables assume a "straight out" climb path.

The one-hour pollutant concentrations can be compared with the worst case National Ambient Air Quality Standards (NAAQS) to provide a point of reference. The predicted ACEE concentrations can be easily compared with the NAAQS by using EPA's Pollution Standards Index (PSI) The PSI normalizes all pollutants on a scale of 0-500 according to the short term NAAQS and health effects. Thus, all pollutants can be compared at the time. The 5-km point is probably the best to use when determining the overall impact of aircraft on air quality. The centerline pollutant concentrations 6 km to 35 km can be used to determine aircraft air quality impact off base.

Any pollutant concentration exceeding 50 percent of the one-hour NAAQS* should be examined more closely using AQAM or other techniques. An AQAM analysis would use specific meteorological conditions for the base. AQAM simulates all special base aircraft operations and gives a much more detailed analysis of pollutant concentrations. If ACEE air pollution concentrations are below 50 percent of the worst case one-hour standards, the base aircraft operations have little adverse effect on air quality and further analysis is not required.

* Special attention should be given to state and local air pollution standards where applicable.

SECTION VI

CONCLUSIONS

ACEE is a preliminary screening procedure to determine the impact of aircraft on ambient air quality. The preliminary impact analysis is performed at base level, saving time and manpower. ACEE is not site specific and can be used at any US Air Force base. ACEE contains all the information required to perform a preliminary air quality impact analysis including: (1) present Air Force aircraft engine emissions factors, (2) LTO and TGO cycle emission factors and (3) climbout aircraft downfield dispersion data. ACEE contains the procedures and examples needed to make preliminary aircraft impact analyses.

ACEE includes procedures to: (1) calculate the annual aircraft emissions at an Air Force base and (2) estimate the one-hour "worst case" ground level air pollution concentrations resulting from an aircraft LTO cycle. The analyses of these results are explained fully in ACEE. The ACEE analyses show one of two things: (1) aircraft pollution impact is negligible, (i.e., aircraft pollution concentrations are below 50 percent of the NAAQS primary standards) or (2) an aircraft air pollution is possible. In the second case, a more detailed analysis using AQAM or other techniques would be required. ACEE will not predict an aircraft air pollution problem. It only indicates the possibility of a problem. ACEE is the first step in the Air Force aircraft air pollution impact analyses.

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APPENDIX A

LTO and TGO Aircraft Emissions

TABLE A-4. A-7 AND A-10 LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

A 7

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	1.36E-02	1.05E-02	1.72E-04	1.72E-05	1.14E-04
TAXI OUT	5.73E-03	4.43E-03	7.23E-05	7.23E-06	4.82E-05
ENGINE CHECK	2.29E-04	2.55E-05	2.67E-03	8.53E-05	1.27E-04
RUNWAY ROLL	4.04E-05	4.49E-06	4.71E-04	1.50E-05	2.24E-05
CLIMB 1	9.92E-05	1.10E-05	1.16E-03	3.69E-05	5.51E-05
CLIMB 2	3.76E-07	4.18E-08	4.39E-06	1.40E-07	2.09E-07
APPROACH 1	5.14E-04	1.11E-04	3.43E-04	1.81E-05	5.04E-05
APPROACH 2	1.91E-04	4.11E-05	1.27E-04	6.73E-06	1.87E-05
LANDING	1.21E-03	9.32E-04	1.52E-05	1.52E-06	1.01E-05
TAXI IN	5.56E-03	4.30E-03	7.01E-05	7.01E-06	4.67E-05
SHUTDOWN	2.72E-03	2.11E-03	3.43E-05	3.43E-06	2.29E-05
TOTAL	3.0E-02	2.2E-02	5.1E-03	2.0E-04	5.2E-04
TOUCH + GO	8.3E-04	1.8E-04	1.7E-03	6.4E-05	1.3E-04

A 10

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	6.25E-03	1.89E-03	1.18E-04	2.36E-06	5.90E-05
TAXI OUT	4.51E-03	1.36E-03	8.50E-05	1.70E-06	4.25E-05
ENGINE CHECK	2.67E-05	1.16E-06	1.16E-04	5.81E-07	1.16E-05
RUNWAY ROLL	2.43E-05	1.06E-06	1.06E-04	5.28E-07	1.06E-05
CLIMB 1	9.35E-05	4.06E-06	4.06E-04	2.03E-06	4.06E-05
CLIMB 2	8.90E-07	3.87E-08	3.87E-06	1.93E-08	3.87E-07
APPROACH 1	4.97E-04	3.59E-05	3.47E-04	1.20E-06	5.99E-05
APPROACH 2	2.53E-04	1.83E-05	1.77E-04	6.10E-07	3.05E-05
LANDING	9.77E-04	2.95E-04	1.84E-05	3.69E-07	9.22E-06
TAXI IN	4.37E-03	1.32E-03	8.24E-05	1.65E-06	4.12E-05
SHUTDOWN	3.13E-03	9.43E-04	5.90E-05	1.18E-06	2.95E-05
TOTAL	2.0E-02	5.9E-03	1.5E-03	1.2E-05	3.3E-04
TOUCH + GO	8.7E-04	6.3E-05	9.6E-04	4.0E-06	1.3E-04

TABLE A-5. A-37 LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

A 37

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	9.75E-03	1.64E-03	7.12E-05	1.64E-07	5.48E-05
TAXI OUT	1.30E-02	2.18E-03	9.46E-05	2.18E-07	7.28E-05
ENGINE CHECK	2.31E-03	6.36E-05	2.07E-04	1.43E-06	7.95E-05
RUNWAY ROLL	3.86E-04	1.06E-05	3.46E-05	2.39E-07	1.33E-05
CLIMB 1	5.76E-04	1.59E-05	5.17E-05	3.58E-07	1.99E-05
CLIMB 2	1.16E-03	3.19E-05	1.04E-04	7.17E-07	3.99E-05
APPROACH 1	2.09E-03	1.70E-04	1.12E-04	5.34E-07	4.86E-05
APPROACH 2	5.43E-04	4.42E-05	2.90E-05	1.39E-07	1.26E-05
LANDING	2.40E-03	4.04E-04	1.75E-05	4.04E-08	1.35E-05
TAXI IN	1.26E-02	2.12E-03	9.17E-05	2.12E-07	7.06E-05
SHUTDOWN	2.44E-03	4.11E-04	1.78E-05	4.11E-08	1.37E-05
TOTAL	4.7E-02	7.1E-03	8.3E-04	4.1E-06	4.4E-04
TOUCH + GO	4.5E-03	2.7E-04	3.0E-04	1.8E-06	1.2E-04

TABLE A-6. B-52D/F AND B-52G LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

B 52D/F

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	3.81E-02	3.39E-02	3.91E-03	5.44E-04	9.41E-04
TAXI OUT	7.42E-02	6.60E-02	7.61E-03	1.06E-03	1.83E-03
ENGINE CHECK	3.81E-02	3.39E-02	3.91E-03	5.44E-04	9.41E-04
RUNWAY ROLL	5.60E-04	2.95E-05	3.24E-03	5.07E-04	2.95E-04
CLIMB 1	6.13E-04	3.23E-05	3.55E-03	5.55E-04	3.23E-04
CLIMB 2	6.77E-04	3.57E-05	3.92E-03	6.13E-04	3.57E-04
APPROACH 1	4.81E-03	8.53E-04	3.53E-03	5.67E-04	6.09E-04
APPROACH 2	1.61E-03	2.85E-04	1.18E-03	1.89E-04	2.04E-04
LANDING	5.44E-03	5.31E-03	1.52E-04	1.10E-05	6.89E-05
TAXI IN	4.29E-02	4.18E-02	1.19E-03	8.68E-05	5.43E-04
SHUTDOWN	1.09E-02	1.06E-02	3.03E-04	2.21E-05	1.38E-04
TOTAL	2.2E-01	1.9E-01	3.3E-02	4.7E-03	6.3E-03
TOUCH + GO	7.8E-03	1.3E-03	1.2E-02	2.0E-03	1.5E-03

B-52G

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	4.65E-02	4.47E-02	1.31E-03	8.35E-05	5.96E-04
TAXI OUT	9.06E-02	8.71E-02	2.56E-03	1.63E-04	1.16E-03
ENGINE CHECK	4.65E-02	4.47E-02	1.31E-03	8.35E-05	5.96E-04
RUNWAY ROLL	4.60E-04	3.07E-05	3.37E-03	5.34E-04	3.07E-04
CLIMB 1	5.04E-04	3.36E-05	3.70E-03	5.85E-04	3.36E-04
CLIMB 2	5.57E-04	3.71E-05	4.08E-03	6.46E-04	3.71E-04
APPROACH 1	8.01E-03	3.07E-03	1.11E-02	9.78E-05	3.34E-04
APPROACH 2	2.68E-03	1.03E-03	3.70E-03	3.27E-05	1.12E-04
LANDING	5.58E-03	5.36E-03	1.57E-04	1.00E-05	7.15E-05
TAXI IN	4.39E-02	4.22E-02	1.24E-03	7.89E-05	5.63E-04
SHUTDOWN	1.12E-02	1.07E-02	3.15E-04	2.00E-05	1.43E-04
TOTAL	2.6E-01	2.4E-01	3.3E-02	2.3E-03	4.6E-03
TOUCH + GO	1.2E-02	4.3E-03	2.3E-02	1.4E-03	1.2E-03

TABLE A-7. B-52H LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

B 52 H

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	4.57E-02	5.82E-02	9.80E-04	1.25E-04	5.44E-04
TAXI OUT	8.91E-02	1.13E-01	1.91E-03	2.44E-04	1.06E-03
ENGINE CHECK	4.57E-02	5.82E-02	9.80E-04	1.25E-04	5.44E-04
RUNWAY ROLL	4.98E-04	1.76E-04	2.93E-03	5.07E-04	2.93E-04
CLIMB 1	5.46E-04	1.93E-04	3.21E-03	5.56E-04	3.21E-04
CLIMB 2	6.03E-04	2.13E-04	3.55E-03	6.14E-04	3.55E-04
APPROACH 1	4.32E-03	1.78E-03	3.97E-03	6.78E-04	6.85E-04
APPROACH 2	1.44E-03	5.95E-04	1.33E-03	2.27E-04	2.29E-04
LANDING	5.48E-03	6.99E-03	1.18E-04	1.50E-05	6.53E-05
TAXI IN	3.24E-02	4.13E-02	6.94E-04	8.87E-05	3.86E-04
SHUTDOWN	8.23E-03	1.05E-02	1.76E-04	2.25E-05	9.80E-05
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TOTAL	2.3E-01	2.9E-01	2.0E-02	3.2E-03	4.6E-03
TOUCH + GO	7.0E-03	2.9E-03	1.2E-02	2.1E-03	1.6E-03

TABLE A-8. B-57A-E AND B-57F LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

B 57A-E

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	1.26E-02	2.13E-03	9.22E-05	2.13E-07	7.09E-05
TAXI OUT	1.09E-02	1.84E-03	7.98E-05	1.84E-07	6.14E-05
ENGINE CHECK	1.11E-04	3.06E-06	9.93E-06	6.88E-08	3.82E-06
RUNWAY ROLL	1.84E-03	4.96E-06	1.41E-04	5.67E-07	7.08E-05
CLIMB 1	4.26E-03	1.15E-05	3.26E-04	1.31E-06	1.64E-04
CLIMB 2	2.58E-04	7.12E-06	2.31E-05	1.60E-07	8.90E-06
APPROACH 1	9.09E-04	7.91E-05	2.22E-05	8.65E-08	1.24E-05
APPROACH 2	9.14E-04	7.95E-05	2.23E-05	8.69E-08	1.24E-05
LANDING	2.03E-03	3.42E-04	1.48E-05	3.42E-08	1.14E-05
TAXI IN	1.06E-02	1.79E-03	7.74E-05	1.79E-07	5.95E-05
SHUTDOWN	6.31E-04	1.06E-04	4.61E-06	1.06E-08	3.55E-06
TOTAL	4.5E-02	6.4E-03	8.1E-04	2.9E-06	4.8E-04
TOUCH + GO	6.4E-03	1.8E-04	4.0E-04	1.7E-06	2.0E-04

B-57 F

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	1.14E-02	1.46E-02	2.45E-04	3.13E-05	1.36E-04
TAXI OUT	9.90E-03	1.26E-02	2.12E-04	2.71E-05	1.18E-04
ENGINE CHECK	1.91E-05	6.75E-06	1.12E-04	1.95E-05	1.12E-05
RUNWAY ROLL	1.08E-04	3.80E-05	6.33E-04	1.09E-04	6.33E-05
CLIMB 1	2.48E-04	8.77E-05	1.46E-03	2.53E-04	1.46E-04
CLIMB 2	4.45E-05	1.57E-05	2.62E-04	4.53E-05	2.62E-05
APPROACH 1	3.11E-04	1.36E-04	2.37E-04	4.08E-05	4.39E-05
APPROACH 2	3.13E-04	1.37E-04	2.38E-04	4.10E-05	4.41E-05
LANDING	1.84E-03	2.34E-03	3.93E-05	5.03E-06	2.19E-05
TAXI IN	9.60E-03	1.22E-02	2.06E-04	2.63E-05	1.14E-04
SHUTDOWN	5.72E-04	7.28E-04	1.22E-05	1.56E-06	6.80E-06
TOTAL	3.4E-02	4.3E-02	3.7E-03	6.0E-04	7.3E-04
TOUCH + GO	9.6E-04	4.2E-04	2.3E-03	3.9E-04	2.7E-04

TABLE A-9. C-5A AND C-5LS LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

C 5A

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	2.30E-02	7.88E-03	1.03E-03	5.14E-06	3.43E-04
TAXI OUT	3.37E-02	1.16E-02	1.51E-03	7.56E-06	5.04E-04
ENGINE CHECK	2.69E-05	7.67E-06	1.07E-03	9.59E-07	3.84E-05
RUNWAY ROLL	2.98E-04	8.51E-05	1.19E-02	1.06E-05	4.26E-04
CLIMB 1	1.42E-04	4.05E-05	5.67E-03	5.06E-06	2.02E-04
CLIMB 2	1.55E-04	4.42E-05	6.19E-03	5.53E-06	2.21E-04
APPROACH 1	3.69E-03	1.24E-03	3.67E-04	1.51E-06	9.41E-05
APPROACH 2	2.33E-03	7.83E-04	2.31E-04	9.49E-07	5.93E-05
LANDING	3.49E-03	1.20E-03	1.56E-04	7.82E-07	5.21E-05
TAXI IN	3.27E-02	1.12E-02	1.47E-03	7.33E-06	4.88E-04
SHUTDOWN	4.59E-03	1.58E-03	2.06E-04	1.03E-06	6.85E-05
TOTAL	1.0E-01	3.6E-02	3.0E-02	4.6E-05	2.5E-03
TOUCH + GO	6.4E-03	2.1E-03	1.3E-02	1.4E-05	6.0E-04

C-5 LS

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	5.14E-03	1.54E-03	3.60E-04	4.11E-06	1.03E-04
TAXI OUT	2.52E-02	7.56E-03	1.76E-03	2.02E-05	5.04E-04
ENGINE CHECK	1.92E-05	3.84E-06	1.53E-03	1.53E-06	3.84E-05
RUNWAY ROLL	1.09E-04	2.18E-05	8.73E-03	8.73E-06	2.18E-04
CLIMB 1	9.38E-05	1.88E-05	7.51E-03	7.51E-06	1.88E-04
CLIMB 2	9.69E-05	1.94E-05	7.75E-03	7.75E-06	1.94E-04
APPROACH 1	5.51E-03	1.65E-03	5.24E-04	4.55E-06	1.14E-04
APPROACH 2	3.35E-03	1.00E-03	3.18E-04	2.77E-06	6.92E-05
LANDING	2.61E-03	7.82E-04	1.83E-04	2.09E-06	5.21E-05
TAXI IN	2.44E-02	7.33E-03	1.71E-03	1.96E-05	4.89E-04
SHUTDOWN	3.43E-03	1.03E-03	2.40E-04	2.74E-06	6.86E-05
TOTAL	7.0E-02	2.1E-02	3.1E-02	8.2E-05	2.0E-03
TOUCH + GO	9.1E-03	2.7E-03	1.7E-02	2.3E-05	5.9E-04

TABLE A-10. C-7 AND C-9A LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

C 7

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	7.02E-04	4.60E-04	8.55E-05	1.82E-05	2.19E-05
TAXI OUT	2.34E-03	1.54E-03	2.86E-04	6.08E-05	7.32E-05
ENGINE CHECK	3.12E-05	5.95E-06	1.38E-04	7.44E-06	1.49E-05
RUNWAY ROLL	1.30E-05	2.48E-06	5.76E-05	3.09E-06	6.19E-06
CLIMB 1	1.89E-05	3.60E-06	8.38E-05	4.50E-06	9.01E-06
CLIMB 2	1.36E-04	2.59E-05	6.03E-04	3.24E-05	6.48E-05
APPROACH 1	8.34E-04	4.66E-04	1.65E-04	3.64E-05	3.76E-05
APPROACH 2	3.94E-04	2.20E-04	7.80E-05	1.72E-05	1.77E-05
LANDING	7.08E-04	4.65E-04	8.63E-05	1.84E-05	2.21E-05
TAXI IN	2.27E-03	1.49E-03	2.77E-04	5.89E-05	7.10E-05
SHUTDOWN	3.51E-04	2.30E-04	4.28E-05	9.10E-06	1.10E-05
TOTAL	7.8E-03	4.9E-03	1.9E-03	2.7E-04	3.5E-04
TOUCH + GO	1.4E-03	7.2E-04	9.5E-04	9.2E-05	1.3E-04

C 9A

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	2.32E-03	4.45E-04	9.28E-05	2.78E-05	4.64E-05
TAXI OUT	5.21E-03	1.00E-03	2.09E-04	6.26E-05	1.04E-04
ENGINE CHECK	1.59E-05	7.94E-06	5.69E-05	3.31E-05	1.32E-05
RUNWAY ROLL	1.31E-04	6.56E-05	4.70E-04	2.73E-04	1.09E-04
CLIMB 1	1.15E-04	5.77E-05	4.13E-04	2.40E-04	9.61E-05
CLIMB 2	1.23E-04	6.17E-05	4.42E-04	2.57E-04	1.03E-04
APPROACH 1	3.12E-03	6.01E-04	1.42E-04	5.27E-05	6.75E-05
APPROACH 2	1.62E-03	3.11E-04	7.34E-05	2.73E-05	3.50E-05
LANDING	1.10E-03	2.10E-04	4.38E-05	1.31E-05	2.19E-05
TAXI IN	5.06E-03	9.71E-04	2.02E-04	6.07E-05	1.01E-04
SHUTDOWN	2.17E-04	4.18E-05	8.70E-06	2.61E-06	4.35E-06
TOTAL	1.9E-02	3.8E-03	2.2E-03	1.1E-03	7.0E-04
TOUCH + GO	5.0E-03	1.0E-03	1.1E-03	6.0E-04	3.1E-04

TABLE A-11. C-97 AND C-119 LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

C 97

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	4.73E-02	1.22E-02	6.36E-05	3.82E-03	3.82E-05
TAXI OUT	2.73E-02	7.02E-03	3.67E-05	2.20E-03	2.20E-05
ENGINE CHECK	1.28E-01	2.25E-03	1.23E-03	2.21E-03	6.63E-05
RUNWAY ROLL	2.77E-02	4.87E-04	2.65E-04	4.77E-04	1.43E-05
CLIMB 1	2.95E-02	5.18E-04	2.82E-04	5.08E-04	1.52E-05
CLIMB 2	3.03E-02	5.32E-04	2.90E-04	5.22E-04	1.57E-05
APPROACH 1	4.66E-02	6.37E-04	6.31E-04	2.69E-03	4.04E-05
APPROACH 2	2.49E-02	3.40E-04	3.37E-04	1.44E-03	2.16E-05
LANDING	6.03E-03	1.55E-03	8.12E-06	4.87E-04	4.87E-06
TAXI IN	2.65E-02	6.80E-03	3.56E-05	2.14E-03	2.14E-05
SHUTDOWN	6.30E-03	1.62E-03	8.49E-06	5.09E-04	5.09E-06
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TOTAL	4.0E-01	3.4E-02	3.2E-03	1.7E-02	2.7E-04
TOUCH + GO	1.3E-01	2.1E-03	1.6E-03	5.2E-03	9.5E-05

C 119

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	3.85E-03	9.89E-04	5.18E-06	3.11E-04	3.11E-06
TAXI OUT	1.19E-02	3.06E-03	1.60E-05	9.61E-04	9.61E-06
ENGINE CHECK	1.64E-03	2.89E-05	1.57E-05	2.83E-05	8.49E-07
RUNWAY ROLL	1.15E-02	2.03E-04	1.10E-04	1.99E-04	5.97E-06
CLIMB 1	1.13E-02	1.99E-04	1.08E-04	1.95E-04	5.85E-06
CLIMB 2	1.82E-02	3.19E-04	1.74E-04	3.13E-04	9.39E-06
APPROACH 1	1.78E-02	2.44E-04	2.41E-04	1.03E-03	1.55E-05
APPROACH 2	9.56E-03	1.31E-04	1.30E-04	5.53E-04	8.30E-06
LANDING	2.34E-03	6.02E-04	3.15E-06	1.89E-04	1.89E-06
TAXI IN	1.15E-02	2.97E-03	1.55E-05	9.32E-04	9.32E-06
SHUTDOWN	3.61E-04	9.27E-05	4.85E-07	2.91E-05	2.91E-07
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TOTAL	1.0E-01	8.8E-03	8.2E-04	4.7E-03	7.0E-05
TOUCH + GO	5.8E-02	9.2E-04	6.7E-04	2.1E-03	4.0E-05

TABLE A-12. C-130A-G AND C-130H LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

C 130

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	1.96E-03	1.29E-03	2.39E-04	5.10E-05	6.14E-05
TAXI OUT	1.93E-02	1.27E-02	2.35E-03	5.00E-04	6.03E-04
ENGINE CHECK	6.25E-04	1.19E-04	2.77E-03	1.49E-04	2.97E-04
RUNWAY ROLL	1.19E-04	2.27E-05	5.28E-04	2.84E-05	5.68E-05
CLIMB 1	9.47E-05	1.80E-05	4.19E-04	2.25E-05	4.51E-05
CLIMB 2	8.78E-05	1.67E-05	3.89E-04	2.09E-05	4.18E-05
APPROACH 1	1.75E-03	9.79E-04	3.47E-04	7.66E-05	7.90E-05
APPROACH 2	9.03E-04	5.04E-04	1.79E-04	3.95E-05	4.07E-05
LANDING	1.34E-03	8.79E-04	1.63E-04	3.47E-05	4.19E-05
TAXI IN	1.87E-02	1.23E-02	2.28E-03	4.85E-04	5.85E-04
SHUTDOWN	1.75E-03	1.15E-03	2.14E-04	4.55E-05	5.48E-05
TOTAL	4.7E-02	3.0E-02	9.9E-03	1.5E-03	1.9E-03
TOUCH + GO	2.9E-03	1.5E-03	1.4E-03	1.6E-04	2.1E-04

C130 H

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	7.56E-04	6.30E-04	1.00E-04	1.59E-05	4.17E-05
TAXI OUT	7.42E-03	6.19E-03	9.84E-04	1.56E-04	4.10E-04
ENGINE CHECK	5.79E-04	7.23E-05	4.23E-03	2.57E-04	3.62E-04
RUNWAY ROLL	1.10E-04	1.38E-05	8.07E-04	4.90E-05	6.90E-05
CLIMB 1	8.77E-05	1.10E-05	6.41E-04	3.89E-05	5.48E-05
CLIMB 2	8.14E-05	1.02E-05	5.95E-04	3.61E-05	5.09E-05
APPROACH 1	6.71E-04	2.69E-04	2.92E-04	3.71E-05	7.90E-05
APPROACH 2	3.46E-04	1.38E-04	1.51E-04	1.91E-05	4.07E-05
LANDING	5.15E-04	4.30E-04	6.83E-05	1.08E-05	2.85E-05
TAXI IN	7.20E-03	6.00E-03	9.54E-04	1.51E-04	3.98E-04
SHUTDOWN	6.75E-04	5.63E-04	8.94E-05	1.42E-05	3.73E-05
TOTAL	1.8E-02	1.4E-02	8.9E-03	7.8E-04	1.6E-03
TOUCH + GO	1.2E-03	4.4E-04	1.7E-03	1.3E-04	2.3E-04

TABLE A-13. KC-135A AND C-135B LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

KC 135A

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	2.46E-02	2.00E-02	9.07E-04	4.91E-05	3.78E-04
TAXI OUT	4.32E-02	3.51E-02	1.59E-03	8.64E-05	6.64E-04
ENGINE CHECK	2.46E-02	2.00E-02	9.07E-04	4.91E-05	3.78E-04
RUNWAY ROLL	3.45E-04	2.88E-05	1.63E-03	1.21E-04	1.44E-04
CLIMB 1	4.05E-04	3.37E-05	1.91E-03	1.42E-04	1.69E-04
CLIMB 2	5.74E-04	4.79E-05	2.70E-03	2.01E-04	2.39E-04
APPROACH 1	5.74E-03	2.51E-03	5.83E-04	3.88E-05	1.77E-04
APPROACH 2	1.48E-03	6.48E-04	1.51E-04	1.00E-05	4.56E-05
LANDING	2.93E-03	2.39E-03	1.08E-04	5.87E-06	4.51E-05
TAXI IN	2.09E-02	1.70E-02	7.73E-04	4.19E-05	3.22E-04
SHUTDOWN	5.53E-03	4.50E-03	2.04E-04	1.11E-05	8.50E-05
TOTAL	1.3E-01	1.0E-01	1.1E-02	7.6E-04	2.6E-03
TOUCH + GO	8.3E-03	3.3E-03	5.5E-03	4.0E-04	6.4E-04

C 135B

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	4.57E-02	5.82E-02	9.80E-04	1.25E-04	5.44E-04
TAXI OUT	4.02E-02	5.12E-02	8.61E-04	1.10E-04	4.78E-04
ENGINE CHECK	9.56E-04	3.37E-04	5.62E-03	9.73E-04	5.62E-04
RUNWAY ROLL	2.30E-04	8.12E-05	1.35E-03	2.34E-04	1.35E-04
CLIMB 1	2.70E-04	9.52E-05	1.59E-03	2.75E-04	1.59E-04
CLIMB 2	3.83E-04	1.35E-04	2.25E-03	3.90E-04	2.25E-04
APPROACH 1	2.86E-03	1.32E-03	1.37E-03	2.23E-04	2.86E-04
APPROACH 2	7.40E-04	3.40E-04	3.55E-04	5.77E-05	7.40E-05
LANDING	2.73E-03	3.48E-03	5.85E-05	7.48E-06	3.25E-05
TAXI IN	3.90E-02	4.96E-02	8.35E-04	1.07E-04	4.64E-04
SHUTDOWN	1.03E-02	1.31E-02	2.20E-04	2.82E-05	1.22E-04
TOTAL	1.4E-01	1.8E-01	1.5E-02	2.5E-03	3.1E-03
TOUCH + GO	4.3E-03	1.9E-03	5.7E-03	9.6E-04	7.5E-04

TABLE A-14. C-121 AND C-141A LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

C 121

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	3.61E-02	9.27E-03	4.85E-05	2.91E-03	2.91E-05
TAXI OUT	2.08E-02	5.35E-03	2.80E-05	1.68E-03	1.68E-05
ENGINE CHECK	9.85E-02	1.73E-03	9.43E-04	1.70E-03	5.09E-05
RUNWAY ROLL	2.13E-02	3.74E-04	2.04E-04	3.67E-04	1.10E-05
CLIMB 1	2.57E-02	4.53E-04	2.46E-04	4.44E-04	1.33E-05
CLIMB 2	2.66E-02	4.68E-04	2.55E-04	4.59E-04	1.38E-05
APPROACH 1	3.58E-02	4.89E-04	4.85E-04	2.07E-03	3.10E-05
APPROACH 2	1.91E-02	2.62E-04	2.59E-04	1.11E-03	1.66E-05
LANDING	4.60E-03	1.18E-03	6.19E-06	3.72E-04	3.72E-06
TAXI IN	2.02E-02	5.19E-03	2.72E-05	1.63E-03	1.63E-05
SHUTDOWN	4.81E-03	1.24E-03	6.47E-06	3.88E-04	3.88E-06
TOTAL	3.1E-01	2.6E-02	2.5E-03	1.3E-02	2.1E-04
TOUCH + GO	1.1E-01	1.7E-03	1.3E-03	4.1E-03	7.6E-05

C 141A

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	3.00E-02	2.48E-02	5.81E-04	3.55E-05	3.23E-04
TAXI OUT	2.83E-02	2.34E-02	5.47E-04	3.35E-05	3.04E-04
ENGINE CHECK	2.11E-05	7.90E-07	3.16E-04	2.40E-05	2.63E-05
RUNWAY ROLL	1.45E-04	5.45E-06	2.18E-03	1.65E-04	1.82E-04
CLIMB 1	1.11E-04	4.15E-06	1.66E-03	1.26E-04	1.38E-04
CLIMB 2	1.13E-04	4.23E-06	1.69E-03	1.28E-04	1.41E-04
APPROACH 1	1.96E-03	5.15E-04	5.43E-04	5.58E-05	1.43E-04
APPROACH 2	1.49E-03	3.91E-04	4.13E-04	4.24E-05	1.09E-04
LANDING	4.19E-03	3.47E-03	8.10E-05	4.95E-06	4.50E-05
TAXI IN	2.74E-02	2.27E-02	5.31E-04	3.24E-05	2.95E-04
SHUTDOWN	4.50E-03	3.73E-03	8.71E-05	5.32E-06	4.84E-05
TOTAL	9.8E-02	7.9E-02	8.6E-03	6.5E-04	1.8E-03
TOUCH + GO	3.7E-03	9.7E-04	4.5E-03	3.6E-04	5.5E-04

TABLE A-15. F-100 LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

F 100

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	3.53E-03	2.94E-03	1.13E-04	7.84E-06	4.90E-05
TAXI OUT	1.37E-02	1.14E-02	4.36E-04	3.04E-05	1.90E-04
ENGINE CHECK	6.98E-05	3.49E-06	3.42E-04	6.98E-05	3.49E-05
RUNWAY ROLL	8.13E-04	2.03E-06	6.32E-04	3.05E-05	2.03E-04
CLIMB 1	6.45E-04	1.61E-06	5.01E-04	2.42E-05	1.61E-04
CLIMB 2	6.44E-05	3.22E-06	3.16E-04	6.44E-05	3.22E-05
APPROACH 1	5.71E-04	1.53E-04	1.57E-04	2.62E-05	3.64E-05
APPROACH 2	2.02E-04	5.40E-05	5.53E-05	9.25E-06	1.29E-05
LANDING	7.42E-04	6.19E-04	2.37E-05	1.65E-06	1.03E-05
TAXI IN	1.32E-02	1.10E-02	4.23E-04	2.94E-05	1.84E-04
SHUTDOWN	5.79E-04	4.82E-04	1.85E-05	1.29E-06	8.04E-06
TOTAL	3.4E-02	2.7E-02	3.0E-03	2.9E-04	9.2E-04
TOUCH + GO	1.5E-03	2.2E-04	1.1E-03	1.3E-04	2.5E-04

TABLE A-16. F-101 AND F-102 LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

F 101

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	7.06E-03	5.88E-03	2.25E-04	1.57E-05	9.80E-05
TAXI OUT	7.96E-03	6.63E-03	2.54E-04	1.77E-05	1.11E-04
ENGINE CHECK	4.65E-04	2.33E-05	2.28E-03	4.65E-04	2.33E-04
RUNWAY ROLL	6.22E-04	1.55E-06	4.83E-04	2.33E-05	1.55E-04
CLIMB 1	1.31E-03	3.28E-06	1.02E-03	4.91E-05	3.28E-04
CLIMB 2	7.00E-05	3.50E-06	3.43E-04	7.00E-05	3.50E-05
APPROACH 1	9.59E-04	2.57E-04	2.63E-04	4.40E-05	6.11E-05
APPROACH 2	4.16E-04	1.11E-04	1.14E-04	1.91E-05	2.65E-05
LANDING	1.37E-03	1.14E-03	4.38E-05	3.04E-06	1.90E-05
TAXI IN	7.72E-03	6.43E-03	2.46E-04	1.71E-05	1.07E-04
SHUTDOWN	2.31E-03	1.93E-03	7.39E-05	5.14E-06	3.21E-05
TOTAL	3.0E-02	2.2E-02	5.3E-03	7.3E-04	1.2E-03
TOUCH + GO	2.8E-03	3.9E-04	1.8E-03	1.9E-04	4.6E-04

F 102

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	4.63E-03	3.86E-03	1.48E-04	1.03E-05	6.43E-05
TAXI OUT	3.98E-03	3.32E-03	1.27E-04	8.84E-06	5.53E-05
ENGINE CHECK	2.33E-04	1.16E-05	1.14E-03	2.33E-04	1.16E-04
RUNWAY ROLL	2.73E-04	6.81E-07	2.12E-04	1.02E-05	6.81E-05
CLIMB 1	4.36E-04	1.09E-06	3.39E-04	1.63E-05	1.09E-04
CLIMB 2	3.76E-05	1.88E-06	1.84E-04	3.76E-05	1.88E-05
APPROACH 1	5.54E-04	1.48E-04	1.52E-04	2.54E-05	3.53E-05
APPROACH 2	2.05E-04	5.49E-05	5.62E-05	9.41E-06	1.31E-05
LANDING	6.48E-04	5.40E-04	2.07E-05	1.44E-06	9.00E-06
TAXI IN	3.86E-03	3.21E-03	1.23E-04	8.57E-06	5.36E-05
SHUTDOWN	1.16E-03	9.64E-04	3.70E-05	2.57E-06	1.61E-05
TOTAL	1.6E-02	1.2E-02	2.5E-03	3.6E-04	5.6E-04
TOUCH + GO	1.2E-03	2.1E-04	7.6E-04	9.4E-05	1.8E-04

TABLE A-17. F-104A AND F-104C LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

F 104A

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	2.82E-03	5.95E-04	1.24E-04	2.48E-05	4.96E-05
TAXI OUT	1.44E-02	3.02E-03	6.30E-04	1.26E-04	2.52E-04
ENGINE CHECK	1.19E-04	1.08E-05	4.81E-04	1.19E-04	5.40E-05
RUNWAY ROLL	3.60E-04	9.00E-07	2.80E-04	1.35E-05	9.00E-05
CLIMB 1	3.89E-04	9.72E-07	3.02E-04	1.46E-05	9.72E-05
CLIMB 2	4.60E-05	4.18E-06	1.86E-04	4.60E-05	2.09E-05
APPROACH 1	4.92E-04	6.24E-05	1.42E-04	4.85E-05	3.46E-05
APPROACH 2	1.16E-04	1.47E-05	3.35E-05	1.14E-05	8.17E-06
LANDING	6.46E-04	1.36E-04	2.83E-05	5.66E-06	1.13E-05
TAXI IN	1.39E-02	2.93E-03	6.11E-04	1.22E-04	2.44E-04
SHUTDOWN	2.82E-04	5.95E-05	1.24E-05	2.48E-06	4.96E-06
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TOTAL	3.4E-02	6.8E-03	2.8E-03	5.3E-04	8.7E-04
TOUCH + GO	1.1E-03	8.5E-05	6.9E-04	1.3E-04	1.6E-04

F104C

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	1.61E-03	3.61E-04	1.08E-04	9.22E-06	4.01E-05
TAXI OUT	8.16E-03	1.83E-03	5.50E-04	4.68E-05	2.04E-04
ENGINE CHECK	1.07E-04	3.56E-06	8.79E-04	1.32E-04	5.94E-05
RUNWAY ROLL	3.89E-04	9.73E-07	3.03E-04	1.46E-05	9.73E-05
CLIMB 1	4.21E-04	1.05E-06	3.27E-04	1.58E-05	1.05E-04
CLIMB 2	4.14E-05	1.38E-06	3.40E-04	5.10E-05	2.30E-05
APPROACH 1	1.21E-03	2.68E-04	2.25E-04	3.49E-05	4.25E-05
APPROACH 2	2.94E-04	6.50E-05	5.47E-05	8.46E-06	1.03E-05
LANDING	3.89E-04	8.73E-05	2.62E-05	2.23E-06	9.70E-06
TAXI IN	7.92E-03	1.78E-03	5.33E-04	4.54E-05	1.97E-04
SHUTDOWN	1.61E-04	3.61E-05	1.08E-05	9.22E-07	4.01E-06
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TOTAL	2.1E-02	4.4E-03	3.4E-03	3.6E-04	7.9E-04
TOUCH + GO	2.0E-03	3.4E-04	9.9E-04	1.2E-04	1.8E-04

TABLE A-18. F-105 AND F-106 LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

F 105

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	4.44E-03	2.72E-03	1.86E-04	1.65E-05	7.16E-05
TAXI OUT	1.42E-02	8.69E-03	5.94E-04	5.26E-05	2.29E-04
ENGINE CHECK	1.23E-04	2.47E-05	8.23E-04	8.56E-05	8.23E-05
RUNWAY ROLL	1.49E-04	2.98E-05	9.92E-04	1.56E-04	9.92E-05
CLIMB 1	2.04E-04	4.09E-05	1.36E-03	2.14E-04	1.36E-04
CLIMB 2	4.62E-05	9.24E-06	3.08E-04	3.20E-05	3.08E-05
APPROACH 1	1.12E-03	6.06E-04	6.21E-05	5.55E-06	2.22E-05
APPROACH 2	3.23E-04	1.75E-04	1.80E-05	1.60E-06	6.42E-06
LANDING	7.81E-04	4.79E-04	3.28E-05	2.90E-06	1.26E-05
TAXI IN	1.37E-02	8.42E-03	5.76E-04	5.10E-05	2.22E-04
SHUTDOWN	5.82E-04	3.57E-04	2.44E-05	2.16E-06	9.39E-06
TOTAL	3.6E-02	2.2E-02	5.0E-03	6.2E-04	9.2E-04
TOUCH + GO	1.7E-03	8.4E-04	1.8E-03	2.6E-04	2.0E-04

F 106

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	8.07E-03	6.76E-03	2.16E-04	2.16E-05	9.39E-05
TAXI OUT	6.94E-03	5.81E-03	1.86E-04	1.86E-05	8.07E-05
ENGINE CHECK	2.54E-04	1.96E-05	2.35E-03	2.11E-04	1.96E-04
RUNWAY ROLL	5.94E-04	1.49E-06	4.62E-04	2.23E-05	1.49E-04
CLIMB 1	6.58E-04	1.64E-06	5.12E-04	2.47E-05	1.64E-04
CLIMB 2	3.79E-05	2.92E-06	3.50E-04	3.15E-05	2.92E-05
APPROACH 1	8.64E-04	2.57E-04	2.12E-04	2.17E-05	4.94E-05
APPROACH 2	3.20E-04	9.52E-05	7.87E-05	8.05E-06	1.83E-05
LANDING	1.13E-03	9.46E-04	3.02E-05	3.02E-06	1.31E-05
TAXI IN	6.73E-03	5.63E-03	1.80E-04	1.80E-05	7.82E-05
SHUTDOWN	2.02E-03	1.69E-03	5.40E-05	5.40E-06	2.35E-05
TOTAL	2.8E-02	2.1E-02	4.6E-03	3.9E-04	8.9E-04
TOUCH + GO	1.9E-03	3.7E-04	1.2E-03	9.1E-05	2.7E-04

TABLE A-19. F-4C/F AND F-4E LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

F 4-C/F

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	6.23E-03	1.31E-03	2.73E-04	5.47E-05	1.09E-04
TAXI OUT	6.15E-03	1.30E-03	2.70E-04	5.40E-05	1.08E-04
ENGINE CHECK	2.38E-04	2.16E-05	9.61E-04	2.38E-04	1.08E-04
RUNWAY ROLL	5.47E-04	1.37E-06	4.25E-04	2.05E-05	1.37E-04
CLIMB 1	7.74E-04	1.93E-06	6.02E-04	2.90E-05	1.93E-04
CLIMB 2	8.99E-05	8.17E-06	3.64E-04	8.99E-05	4.09E-05
APPROACH 1	9.32E-04	1.09E-04	4.76E-04	1.78E-04	9.91E-05
APPROACH 2	3.37E-04	3.94E-05	1.72E-04	6.45E-05	3.58E-05
LANDING	1.11E-03	2.34E-04	4.87E-05	9.74E-06	1.95E-05
TAXI IN	5.97E-03	1.26E-03	2.62E-04	5.23E-05	1.05E-04
SHUTDOWN	3.90E-04	8.20E-05	1.71E-05	3.42E-06	6.83E-06
TOTAL	2.3E-02	4.4E-03	3.9E-03	7.9E-04	9.6E-04
TOUCH + GO	2.2E-03	1.6E-04	1.7E-03	3.7E-04	3.8E-04

F 4 E

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	4.11E-03	9.23E-04	2.77E-04	2.36E-05	1.03E-04
TAXI OUT	4.06E-03	9.11E-04	2.73E-04	2.33E-05	1.01E-04
ENGINE CHECK	2.14E-04	7.13E-07	1.76E-03	2.64E-04	1.19E-04
RUNWAY ROLL	5.93E-04	1.48E-06	4.61E-04	2.22E-05	1.48E-04
CLIMB 1	8.39E-04	2.10E-06	6.52E-04	3.15E-05	2.10E-04
CLIMB 2	8.09E-05	2.70E-07	6.65E-04	9.98E-05	4.49E-05
APPROACH 1	2.75E-03	6.14E-04	5.45E-04	8.52E-05	9.91E-05
APPROACH 2	9.49E-04	2.12E-04	1.88E-04	2.95E-05	3.43E-05
LANDING	6.76E-04	1.52E-04	4.55E-05	3.88E-06	1.69E-05
TAXI IN	3.94E-03	8.84E-04	2.65E-04	2.26E-05	9.82E-05
SHUTDOWN	2.57E-04	5.77E-05	1.73E-05	1.47E-06	6.41E-06
TOTAL	1.8E-02	3.8E-03	5.1E-03	6.1E-04	9.8E-04
TOUCH + GO	4.6E-03	8.3E-04	2.1E-03	2.6E-04	3.9E-04

TABLE A-20. F-5 AND F-111A LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

F 5

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	6.31E-03	1.06E-03	4.61E-05	1.06E-07	3.55E-05
TAXI OUT	1.18E-02	1.99E-03	8.62E-05	1.99E-07	6.63E-05
ENGINE CHECK	8.31E-04	2.29E-05	7.45E-05	5.16E-07	2.87E-05
RUNWAY ROLL	1.92E-03	5.16E-06	1.47E-04	5.89E-07	7.37E-05
CLIMB 1	9.63E-04	2.59E-06	7.36E-05	2.96E-07	3.70E-05
CLIMB 2	5.55E-04	1.53E-05	4.98E-05	3.45E-07	1.91E-05
APPROACH 1	2.36E-03	2.05E-04	5.76E-05	2.24E-07	3.20E-05
APPROACH 2	3.54E-04	3.08E-05	8.67E-06	3.37E-08	4.81E-06
LANDING	1.77E-03	2.98E-04	1.29E-05	2.98E-08	9.92E-06
TAXI IN	1.14E-02	1.93E-03	8.36E-05	1.93E-07	6.43E-05
SHUTDOWN	8.33E-04	1.40E-04	6.08E-06	1.40E-08	4.68E-06
TOTAL	3.9E-02	5.7E-03	6.5E-04	2.5E-06	3.8E-04
TOUCH + GO	4.3E-03	2.6E-04	1.9E-04	9.3E-07	9.5E-05

F 111 A

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	5.74E-03	4.94E-03	1.83E-04	4.78E-07	7.97E-05
TAXI OUT	1.68E-02	1.44E-02	5.36E-04	1.40E-06	2.33E-04
ENGINE CHECK	1.04E-04	3.90E-06	1.56E-03	5.21E-05	1.30E-04
RUNWAY ROLL	1.21E-03	1.89E-06	1.70E-03	3.98E-04	1.89E-04
CLIMB 1	1.49E-03	2.32E-06	2.09E-03	4.88E-04	2.32E-04
CLIMB 2	2.23E-05	8.34E-07	3.34E-04	1.11E-05	2.78E-05
APPROACH 1	5.58E-04	1.27E-04	2.91E-04	3.03E-06	6.07E-05
APPROACH 2	2.05E-04	4.69E-05	1.07E-04	1.12E-06	2.23E-05
LANDING	1.26E-03	1.09E-03	4.03E-05	1.05E-07	1.75E-05
TAXI IN	1.63E-02	1.40E-02	5.19E-04	1.36E-06	2.26E-04
SHUTDOWN	1.20E-03	1.04E-03	3.84E-05	1.00E-07	1.67E-05
TOTAL	4.5E-02	3.6E-02	7.4E-03	9.6E-04	1.2E-03
TOUCH + GO	2.3E-03	1.9E-04	2.9E-03	5.0E-04	3.5E-04

TABLE A-21. F-111D/E AND F-111F LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

F111 D/E

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	4.27E-03	1.69E-03	2.58E-04	1.78E-06	8.89E-05
TAXI OUT	1.25E-02	4.93E-03	7.53E-04	5.19E-06	2.60E-04
ENGINE CHECK	1.34E-04	1.92E-05	5.38E-03	4.61E-05	1.92E-04
RUNWAY ROLL	1.06E-03	2.66E-06	8.28E-04	3.99E-05	2.66E-04
CLIMB 1	1.31E-03	3.27E-06	1.02E-03	4.90E-05	3.27E-04
CLIMB 2	2.87E-05	4.11E-06	1.15E-03	9.86E-06	4.11E-05
APPROACH 1	6.01E-04	1.64E-04	3.82E-04	4.85E-06	6.07E-05
APPROACH 2	2.07E-04	5.65E-05	1.32E-04	1.67E-06	2.09E-05
LANDING	8.20E-04	3.25E-04	4.95E-05	3.42E-07	1.71E-05
TAXI IN	1.21E-02	4.79E-03	7.30E-04	5.04E-06	2.52E-04
SHUTDOWN	8.94E-04	3.54E-04	5.40E-05	3.73E-07	1.86E-05
TOTAL	3.4E-02	1.2E-02	1.1E-02	1.6E-04	1.5E-03
TOUCH + GO	2.2E-03	2.3E-04	2.8E-03	6.7E-05	4.6E-04

F111 F

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	4.27E-03	1.69E-03	2.58E-04	1.78E-06	8.89E-05
TAXI OUT	1.25E-02	4.93E-03	7.53E-04	5.19E-06	2.60E-04
ENGINE CHECK	1.34E-04	1.92E-05	5.38E-03	4.61E-05	1.92E-04
RUNWAY ROLL	1.06E-03	2.66E-06	8.28E-04	3.99E-05	2.66E-04
CLIMB 1	1.31E-03	3.27E-06	1.02E-03	4.90E-05	3.27E-04
CLIMB 2	2.87E-05	4.11E-06	1.15E-03	9.86E-06	4.11E-05
APPROACH 1	6.01E-04	1.64E-04	3.82E-04	4.85E-06	6.07E-05
APPROACH 2	2.21E-04	6.02E-05	1.41E-04	1.79E-06	2.23E-05
LANDING	9.38E-04	3.71E-04	5.67E-05	3.91E-07	1.95E-05
TAXI IN	1.21E-02	4.79E-03	7.30E-04	5.04E-06	2.52E-04
SHUTDOWN	8.94E-04	3.54E-04	5.40E-05	3.73E-07	1.86E-05
TOTAL	3.4E-02	1.2E-02	1.1E-02	1.6E-04	1.5E-03
TOUCH + GO	2.2E-03	2.4E-04	2.9E-03	6.7E-05	4.6E-04

TABLE A-22. F-15 AND F-16 LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

F 15

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	3.86E-03	5.14E-04	5.30E-04	1.93E-05	1.61E-04
TAXI OUT	3.24E-03	4.32E-04	4.45E-04	1.62E-05	1.35E-04
ENGINE CHECK	1.76E-05	1.95E-06	5.27E-04	6.63E-06	1.95E-05
RUNWAY ROLL	5.57E-04	1.39E-06	4.33E-04	2.09E-05	1.39E-04
CLIMB 1	9.19E-04	2.30E-06	7.15E-04	3.45E-05	2.30E-04
CLIMB 2	4.12E-05	4.58E-06	1.24E-03	1.56E-05	4.58E-05
APPROACH 1	2.79E-04	9.15E-05	3.23E-04	1.30E-05	4.82E-05
APPROACH 2	1.62E-04	5.30E-05	1.87E-04	7.54E-06	2.79E-05
LANDING	5.86E-04	7.81E-05	8.06E-05	2.93E-06	2.44E-05
TAXI IN	3.14E-03	4.19E-04	4.32E-04	1.57E-05	1.31E-04
SHUTDOWN	1.29E-04	1.71E-05	1.77E-05	6.43E-07	5.36E-06
TOTAL	1.3E-02	1.6E-03	4.9E-03	1.5E-04	9.7E-04
TOUCH + GO	1.4E-03	1.5E-04	2.6E-03	7.3E-05	3.6E-04

F 16

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	4.11E-03	5.48E-04	5.66E-04	2.06E-05	1.71E-04
TAXI OUT	1.08E-03	1.44E-04	1.49E-04	5.40E-06	4.50E-05
ENGINE CHECK	2.32E-05	2.58E-06	6.95E-04	8.76E-06	2.58E-05
RUNWAY ROLL	4.72E-06	5.24E-07	1.41E-04	1.78E-06	5.24E-06
CLIMB 1	2.62E-05	2.91E-06	7.85E-04	9.89E-06	2.91E-05
CLIMB 2	3.70E-06	4.12E-07	1.11E-04	1.40E-06	4.12E-06
APPROACH 1	2.31E-05	7.56E-06	2.67E-05	1.07E-06	3.98E-06
APPROACH 2	1.19E-04	3.89E-05	1.37E-04	5.53E-06	2.05E-05
LANDING	3.46E-04	4.62E-05	4.76E-05	1.73E-06	1.44E-05
TAXI IN	1.05E-03	1.40E-04	1.44E-04	5.24E-06	4.37E-05
SHUTDOWN	3.09E-03	4.11E-04	4.24E-04	1.54E-05	1.29E-04
TOTAL	9.9E-03	1.3E-03	3.2E-03	7.7E-05	4.9E-04
TOUCH + GO	1.8E-04	5.1E-05	1.2E-03	1.9E-05	6.2E-05

TABLE A-23. O-1 AND O-2 LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

O 1

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	8.43E-04	2.17E-04	1.25E-06	6.80E-05	6.80E-07
TAXI OUT	7.29E-04	1.88E-04	1.08E-06	5.89E-05	5.89E-07
ENGINE CHECK	2.30E-03	4.04E-05	1.86E-05	3.96E-05	1.19E-06
RUNWAY ROLL	2.23E-04	3.91E-06	1.80E-06	3.84E-06	1.15E-07
CLIMB 1	6.79E-04	1.19E-05	5.51E-06	1.17E-05	3.51E-07
CLIMB 2	2.34E-03	4.11E-05	1.89E-05	4.03E-05	1.21E-06
APPROACH 1	1.00E-03	2.40E-05	1.40E-06	6.39E-05	8.43E-07
APPROACH 2	4.93E-04	1.18E-05	6.91E-07	3.14E-05	4.15E-07
LANDING	2.26E-04	5.80E-05	3.34E-07	1.82E-05	1.82E-07
TAXI IN	7.07E-04	1.82E-04	1.05E-06	5.71E-05	5.71E-07
SHUTDOWN	1.69E-04	4.33E-05	2.49E-07	1.36E-05	1.36E-07
TOTAL	9.7E-03	8.2E-04	5.1E-05	4.1E-04	6.3E-06
TOUCH + GO	4.6E-03	9.2E-05	2.8E-05	1.5E-04	2.9E-06

O 2

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	7.69E-03	1.32E-03	9.98E-06	5.44E-04	5.44E-06
TAXI OUT	3.33E-03	5.69E-04	4.32E-06	2.36E-04	2.36E-06
ENGINE CHECK	2.80E-03	6.12E-05	1.44E-05	5.44E-05	1.63E-06
RUNWAY ROLL	2.71E-04	5.93E-06	1.40E-06	5.27E-06	1.58E-07
CLIMB 1	8.29E-04	1.81E-05	4.27E-06	1.61E-05	4.83E-07
CLIMB 2	2.85E-03	6.23E-05	1.47E-05	5.54E-05	1.66E-06
APPROACH 1	2.70E-03	6.74E-05	1.57E-05	1.17E-04	1.71E-06
APPROACH 2	1.33E-03	3.32E-05	7.73E-06	5.75E-05	8.43E-07
LANDING	1.03E-03	1.76E-04	1.34E-06	7.28E-05	7.28E-07
TAXI IN	3.23E-03	5.52E-04	4.19E-06	2.28E-04	2.28E-06
SHUTDOWN	7.69E-04	1.32E-04	9.98E-07	5.44E-05	5.44E-07
TOTAL	2.7E-02	3.0E-03	7.9E-05	1.4E-03	1.8E-05
TOUCH + GO	7.9E-03	1.9E-04	4.3E-05	2.5E-04	4.8E-06

TABLE A-24. OV-10 LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

OV10

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	1.35E-03	4.20E-04	4.20E-04	2.15E-05	5.67E-05
TAXI OUT	6.19E-04	1.92E-04	1.92E-04	9.88E-06	2.60E-05
ENGINE CHECK	6.26E-05	1.63E-06	2.80E-04	1.93E-05	2.72E-05
RUNWAY ROLL	4.14E-06	1.08E-07	1.85E-05	1.28E-06	1.80E-06
CLIMB 1	1.87E-05	4.88E-07	8.37E-05	5.77E-06	8.13E-06
CLIMB 2	2.01E-05	5.26E-07	9.02E-05	6.22E-06	8.76E-06
APPROACH 1	3.28E-04	1.53E-05	1.62E-04	9.54E-06	1.91E-05
APPROACH 2	2.05E-04	9.52E-06	1.01E-04	5.95E-06	1.19E-05
LANDING	2.29E-04	7.13E-05	7.13E-05	3.66E-06	9.63E-06
TAXI IN	6.00E-04	1.86E-04	1.86E-04	9.58E-06	2.52E-05
SHUTDOWN	1.80E-04	5.59E-05	5.59E-05	2.87E-06	7.56E-06
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TOTAL	3.6E-03	9.5E-04	1.7E-03	9.6E-05	2.0E-04
TOUCH + GO	5.8E-04	2.7E-05	4.5E-04	2.8E-05	4.9E-05

TABLE A-25. T-33 LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

T 33

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	2.88E-03	4.42E-04	3.40E-05	1.66E-05	2.27E-05
TAXI OUT	7.87E-03	1.21E-03	9.30E-05	4.53E-05	6.20E-05
ENGINE CHECK	3.92E-04	6.27E-06	4.51E-05	2.51E-07	1.25E-05
RUNWAY ROLL	4.99E-04	7.98E-06	5.74E-05	3.19E-07	1.60E-05
CLIMB 1	6.60E-04	1.05E-05	7.59E-05	4.22E-07	2.11E-05
CLIMB 2	1.30E-03	2.08E-05	1.50E-04	8.34E-07	4.17E-05
APPROACH 1	2.42E-03	1.86E-04	5.44E-05	1.63E-05	2.86E-05
APPROACH 2	2.01E-03	1.55E-04	4.52E-05	1.36E-05	2.38E-05
LANDING	1.94E-03	2.98E-04	2.29E-05	1.12E-05	1.53E-05
TAXI IN	7.64E-03	1.17E-03	9.02E-05	4.39E-05	6.01E-05
SHUTDOWN	4.61E-04	7.08E-05	5.44E-06	2.65E-06	3.63E-06
TOTAL	2.8E-02	3.6E-03	6.7E-04	1.5E-04	3.1E-04
TOUCH + GO	6.5E-03	3.8E-04	3.4E-04	3.1E-05	1.2E-04

TABLE A-26. T-37 AND T-38 LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

T 37

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	1.71E-03	2.52E-04	1.99E-05	7.30E-06	1.33E-05
TAXI OUT	4.72E-03	6.96E-04	5.49E-05	2.01E-05	3.66E-05
ENGINE CHECK	2.65E-04	4.14E-06	2.98E-05	1.66E-07	8.28E-06
RUNWAY ROLL	1.46E-04	2.28E-06	1.64E-05	9.10E-08	4.55E-06
CLIMB 1	2.73E-04	4.27E-06	3.07E-05	1.71E-07	8.54E-06
CLIMB 2	5.28E-04	8.25E-06	5.94E-05	3.30E-07	1.65E-05
APPROACH 1	1.03E-03	1.07E-04	1.64E-05	2.69E-06	9.62E-06
APPROACH 2	2.09E-04	2.17E-05	3.33E-06	5.48E-07	1.96E-06
LANDING	9.77E-04	1.44E-04	1.14E-05	4.17E-06	7.58E-06
TAXI IN	4.58E-03	6.75E-04	5.33E-05	1.95E-05	3.55E-05
SHUTDOWN	2.70E-04	3.98E-05	3.14E-06	1.15E-06	2.10E-06
TOTAL	1.5E-02	2.0E-03	3.0E-04	5.6E-05	1.4E-04
TOUCH + GO	2.1E-03	1.4E-04	1.1E-04	3.8E-06	3.8E-05

T 38

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	6.34E-03	1.07E-03	4.63E-05	1.07E-07	3.56E-05
TAXI OUT	1.31E-02	2.20E-03	9.55E-05	2.20E-07	7.34E-05
ENGINE CHECK	3.46E-04	9.54E-06	3.10E-05	2.15E-07	1.19E-05
RUNWAY ROLL	9.11E-04	2.45E-06	6.97E-05	2.80E-07	3.50E-05
CLIMB 1	9.63E-04	2.59E-06	7.36E-05	2.96E-07	3.70E-05
CLIMB 2	5.78E-04	1.59E-05	5.18E-05	3.59E-07	1.99E-05
APPROACH 1	2.04E-03	1.66E-04	1.09E-04	5.21E-07	4.74E-05
APPROACH 2	2.59E-04	2.11E-05	1.39E-05	6.63E-08	6.02E-06
LANDING	1.72E-03	2.90E-04	1.26E-05	2.90E-08	9.66E-06
TAXI IN	1.27E-02	2.14E-03	9.26E-05	2.14E-07	7.12E-05
SHUTDOWN	8.53E-04	1.44E-04	6.23E-06	1.44E-08	4.79E-06
TOTAL	4.0E-02	6.1E-03	6.0E-04	2.3E-06	3.5E-04
TOUCH + GO	3.9E-03	2.1E-04	2.5E-04	1.3E-06	1.1E-04

TABLE A-27. T-39 AND T-41 LTO AND TGO EMISSIONS

EMISSIONS BY AIRCRAFT TYPE
(METRIC TONS/LTO CYCLE)

T 39

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	1.13E-03	1.48E-04	2.42E-05	3.22E-07	1.61E-05
TAXI OUT	3.05E-03	4.01E-04	6.55E-05	8.73E-07	4.36E-05
ENGINE CHECK	1.49E-05	3.73E-07	1.72E-05	6.34E-07	3.73E-06
RUNWAY ROLL	3.56E-05	8.89E-07	4.09E-05	1.51E-06	8.89E-06
CLIMB 1	9.26E-05	2.31E-06	1.06E-04	3.93E-06	2.31E-05
CLIMB 2	1.05E-04	2.64E-06	1.21E-04	4.48E-06	2.64E-05
APPROACH 1	9.44E-04	1.05E-04	3.18E-05	5.61E-07	1.87E-05
APPROACH 2	2.91E-04	3.22E-05	9.79E-06	1.73E-07	5.76E-06
LANDING	7.53E-04	9.89E-05	1.61E-05	2.15E-07	1.08E-05
TAXI IN	2.96E-03	3.89E-04	6.35E-05	8.46E-07	4.23E-05
SHUTDOWN	1.47E-04	1.93E-05	3.15E-06	4.20E-08	2.10E-06
	--------	--------	--------	--------	--------
TOTAL	9.5E-03	1.2E-03	5.0E-04	1.4E-05	2.0E-04
TOUCH + GO	1.5E-03	1.4E-04	2.8E-04	9.6E-06	7.6E-05

T 41

OPERATION	CO	HC	NOX	PM	SOX
STARTUP	1.54E-03	2.63E-04	2.00E-06	1.09E-04	1.09E-06
TAXI OUT	1.67E-03	2.85E-04	2.16E-06	1.18E-04	1.18E-06
ENGINE CHECK	1.40E-03	3.06E-05	7.21E-06	2.72E-05	8.16E-07
RUNWAY ROLL	1.36E-04	2.97E-06	6.99E-07	2.64E-06	7.91E-08
CLIMB 1	2.16E-03	4.72E-05	1.11E-05	4.20E-05	1.26E-06
CLIMB 2	9.53E-04	2.08E-05	4.90E-06	1.85E-05	5.55E-07
APPROACH 1	2.70E-04	2.17E-05	7.68E-07	1.69E-05	1.84E-07
APPROACH 2	9.34E-04	7.50E-05	2.66E-06	5.84E-05	6.38E-07
LANDING	5.15E-04	8.80E-05	6.68E-07	3.64E-05	3.64E-07
TAXI IN	1.61E-03	2.76E-04	2.09E-06	1.14E-04	1.14E-06
SHUTDOWN	3.85E-04	6.58E-05	4.99E-07	2.72E-05	2.72E-07
	--------	--------	--------	--------	--------
TOTAL	1.2E-02	1.2E-03	3.5E-05	5.7E-04	7.6E-06
TOUCH + GO	4.4E-03	1.7E-04	2.0E-05	1.4E-04	2.7E-06

APPENDIX B

CONVERSION AND VARIABLES

The following is a list of variables used in the ACEE methodology:

Variable	Variable Names	Units
EGM	Engine Thrust Mode	idle, approach, normal, military takeoff and afterburner
POL	Pollutant Type	CO, H_xC_y, NO_x, PM, SO_x
EMFAC(EGM, POL)	Engine Emission Factor for the specified Thrust Mode and Pollutant Type	mass units pollutants/ 1000 mass units fuel
FLFLW(EGM)	Engine Fuel Flow for the specified Thrust Mode	kg/hr
NOEG	Number of Engines per Aircraft	engines/aircraft

Exponential Notation

The LTO emissions tables were computer generated. The LTO mode pollutant emissions differ by orders of magnitude. To present these data, exponential notation had to be used. The relationship between exponential and scientific notation is:

$$AE \pm N = A \times 10^{\pm N}$$

where: A is a real number
N is a integer or zero

Examples:

$$1.2\ E-02 = 1.2 \times 10^{-2} = 0.012$$

$$1.2\ E+00 = 1.2 \times 10^{0} = 1.2$$

$$1.2\ E+02 = 1.2 \times 10^{2} = 20$$

APPENDIX C

Downfield Pollutant Concentrations Tables

TABLE C-28. A-7 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT A 7 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	1.11	.82	.55	.02	.04
6	1.01	.75	.47	.02	.03
7	.98	.72	.41	.01	.03
8	.98	.73	.37	.01	.03
9	1.01	.76	.33	.01	.02
10	1.05	.79	.30	.01	.02
11	1.09	.82	.28	.01	.02
13	1.14	.86	.25	.01	.02
15	1.15	.87	.22	.01	.02
17	1.13	.86	.20	.01	.02
19	1.10	.84	.18	.01	.02
21	1.06	.81	.16	.01	.02
23	1.01	.77	.15	.01	.02
27	.92	.71	.13	.01	.01
31	.84	.64	.12	.01	.01
35	.77	.59	.10	.00	.01

TABLE C-29. A-10 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT A 10 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	.85	.25	.07	.00	.01
6	.78	.23	.06	.00	.01
7	.75	.22	.06	0.00	.01
8	.74	.22	.05	0.00	.01
9	.75	.22	.05	0.00	.01
10	.77	.23	.05	0.00	.01
11	.79	.24	.04	0.00	.01
13	.80	.24	.04	0.00	.01
15	.80	.24	.04	0.00	.01
17	.78	.23	.03	0.00	.01
19	.75	.22	.03	0.00	.01
21	.72	.22	.03	0.00	.01
23	.68	.21	.03	0.00	.01
27	.62	.19	.02	0.00	.01
31	.57	.17	.02	0.00	.01
35	.52	.16	.02	0.00	.01

TABLE C-30. A-37 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT A 37 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	2.86	.40	.07	0.00	.03
6	2.59	.37	.06	0.00	.03
7	2.44	.35	.05	0.00	.03
8	2.35	.34	.05	0.00	.02
9	2.29	.34	.04	0.00	.02
10	2.26	.34	.04	0.00	.02
11	2.22	.34	.04	0.00	.02
13	2.14	.33	.04	0.00	.02
15	2.04	.32	.03	0.00	.02
17	1.94	.30	.03	0.00	.02
19	1.83	.29	.03	0.00	.02
21	1.73	.27	.03	0.00	.01
23	1.63	.26	.02	0.00	.01
27	1.45	.23	.02	0.00	.01
31	1.31	.21	.02	0.00	.01
35	1.19	.19	.02	0.00	.01

TABLE C-31. B-52D/F WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT B 52D/F NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	15.00	13.52	2.12	.30	.40
6	13.64	12.30	1.85	.26	.36
7	12.77	11.53	1.67	.24	.33
8	12.19	11.02	1.54	.22	.31
9	11.79	10.67	1.44	.20	.30
10	11.47	10.40	1.36	.19	.28
11	11.19	10.14	1.30	.18	.27
13	10.61	9.64	1.19	.17	.26
15	10.02	9.10	1.10	.15	.24
17	9.43	8.57	1.02	.14	.22
19	8.86	8.05	.95	.13	.21
21	8.33	7.57	.89	.12	.20
23	7.85	7.13	.83	.12	.19
27	7.00	6.36	.74	.10	.17
31	6.30	5.73	.66	.09	.15
35	5.72	5.20	.60	.08	.13

TABLE C-32. B-52G WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT B-52G NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	17.46	16.57	1.63	.17	.31
6	15.89	15.10	1.39	.14	.27
7	14.88	14.15	1.22	.12	.25
8	14.20	13.51	1.10	.11	.23
9	13.72	13.07	1.02	.10	.22
10	13.35	12.72	.95	.09	.21
11	13.01	12.40	.89	.09	.20
13	12.34	11.77	.79	.08	.19
15	11.65	11.12	.72	.07	.18
17	10.96	10.47	.66	.06	.17
19	10.30	9.84	.60	.06	.15
21	9.69	9.26	.56	.05	.14
23	9.13	8.72	.52	.05	.14
27	8.14	7.78	.46	.04	.12
31	7.33	7.01	.41	.04	.11
35	6.66	6.37	.37	.03	.10

TABLE C-33. B-52H WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT B 52 H NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	16.42	20.71	1.21	.19	.29
6	14.89	18.79	1.02	.16	.25
7	13.89	17.54	.90	.14	.23
8	13.22	16.71	.81	.13	.21
9	12.74	16.11	.74	.12	.20
10	12.37	15.65	.68	.11	.19
11	12.04	15.24	.64	.10	.18
13	11.40	14.43	.57	.09	.17
15	10.75	13.62	.52	.08	.16
17	10.11	12.82	.47	.07	.15
19	9.51	12.05	.43	.07	.14
21	8.94	11.33	.40	.06	.13
23	8.42	10.68	.37	.06	.12
27	7.52	9.53	.33	.05	.11
31	6.77	8.59	.29	.04	.10
35	6.15	7.80	.26	.04	.09

TABLE C-34. B-57A-E WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT B 57A-E NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	2.63	.33	.06	0.00	.04
6	2.35	.31	.05	0.00	.03
7	2.20	.29	.05	0.00	.03
8	2.11	.29	.04	0.00	.03
9	2.06	.29	.04	0.00	.02
10	2.03	.29	.04	0.00	.02
11	2.01	.29	.03	0.00	.02
13	1.94	.29	.03	0.00	.02
15	1.86	.28	.03	0.00	.02
17	1.77	.27	.03	0.00	.02
19	1.68	.25	.02	0.00	.02
21	1.59	.24	.02	0.00	.01
23	1.50	.23	.02	0.00	.01
27	1.35	.21	.02	0.00	.01
31	1.22	.19	.02	0.00	.01
35	1.11	.17	.02	0.00	.01

TABLE C-35. B-57F WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT B-57 F NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	1.81	2.24	.29	.05	.05
6	1.66	2.06	.24	.04	.04
7	1.59	1.98	.21	.03	.04
8	1.56	1.94	.19	.03	.04
9	1.55	1.94	.17	.03	.03
10	1.56	1.95	.16	.03	.03
11	1.56	1.96	.15	.02	.03
13	1.54	1.94	.13	.02	.03
15	1.50	1.88	.12	.02	.03
17	1.43	1.81	.11	.02	.03
19	1.37	1.72	.10	.02	.02
21	1.30	1.63	.09	.01	.02
23	1.23	1.55	.08	.01	.02
27	1.11	1.40	.07	.01	.02
31	1.00	1.26	.06	.01	.02
35	.91	1.15	.06	.01	.02

TABLE C-36. C-5 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT C 5 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	5.42	1.85	4.47	.01	.23
6	5.10	1.75	3.51	.00	.19
7	4.94	1.69	2.89	.00	.17
8	4.87	1.67	2.49	.00	.15
9	4.85	1.66	2.20	.00	.14
10	4.84	1.66	1.98	.00	.14
11	4.82	1.65	1.81	.00	.13
13	4.72	1.62	1.55	.00	.12
15	4.54	1.56	1.36	.00	.11
17	4.32	1.48	1.22	.00	.10
19	4.10	1.40	1.11	.00	.09
21	3.87	1.33	1.01	.00	.09
23	3.66	1.26	.93	.00	.08
27	3.28	1.13	.81	.00	.07
31	2.96	1.02	.71	.00	.07
35	2.70	.92	.64	.00	.06

TABLE C-37. C-5LS WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT C-5 LS NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	4.10	1.23	3.48	.01	.16
6	3.85	1.15	2.86	.01	.14
7	3.71	1.11	2.46	.01	.13
8	3.62	1.09	2.17	.01	.12
9	3.56	1.07	1.95	.01	.11
10	3.50	1.05	1.77	.00	.11
11	3.43	1.03	1.63	.00	.10
13	3.27	.98	1.41	.00	.10
15	3.08	.92	1.25	.00	.09
17	2.89	.87	1.12	.00	.08
19	2.71	.81	1.02	.00	.08
21	2.54	.76	.93	.00	.07
23	2.39	.72	.86	.00	.07
27	2.12	.64	.75	.00	.06
31	1.90	.57	.66	.00	.05
35	1.72	.52	.59	.00	.05

TABLE C-38. C-7 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT C 7 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	.53	.34	.12	.02	.02
6	.47	.30	.10	.02	.02
7	.44	.28	.09	.01	.02
8	.42	.27	.08	.01	.02
9	.40	.26	.08	.01	.02
10	.39	.25	.08	.01	.02
11	.38	.25	.07	.01	.02
13	.36	.23	.07	.01	.01
15	.34	.22	.06	.01	.01
17	.31	.20	.06	.01	.01
19	.29	.19	.05	.01	.01
21	.27	.18	.05	.01	.01
23	.26	.17	.05	.01	.01
27	.23	.15	.04	.01	.01
31	.20	.13	.04	.01	.01
35	.19	.12	.03	.01	.01

TABLE C-39. C-9 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT C 9 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	1.09	.22	.20	.11	.06
6	.99	.20	.16	.09	.05
7	.93	.19	.14	.07	.04
8	.89	.18	.13	.06	.04
9	.86	.17	.11	.06	.04
10	.84	.17	.11	.05	.03
11	.82	.16	.10	.05	.03
13	.78	.15	.09	.04	.03
15	.73	.14	.08	.04	.03
17	.69	.14	.07	.03	.02
19	.64	.13	.06	.03	.02
21	.60	.12	.06	.03	.02
23	.57	.11	.05	.03	.02
27	.50	.10	.05	.02	.02
31	.45	.09	.04	.02	.02
35	.41	.08	.04	.02	.01

TABLE C-40. C-97 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT C 97 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	36.28	1.84	.31	1.03	.02
6	30.93	1.64	.27	.89	.02
7	27.25	1.53	.23	.81	.02
8	24.59	1.48	.20	.76	.01
9	22.61	1.46	.18	.72	.01
10	21.05	1.46	.17	.70	.01
11	19.78	1.46	.16	.68	.01
13	17.74	1.44	.13	.64	.01
15	16.13	1.40	.12	.61	.01
17	14.79	1.35	.11	.57	.01
19	13.65	1.29	.10	.54	.01
21	12.66	1.23	.09	.51	.01
23	11.81	1.17	.08	.48	.01
27	10.40	1.05	.07	.43	.01
31	9.28	.95	.06	.39	.01
35	8.39	.87	.06	.35	.01

TABLE C-41. C-119 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT C119 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	7.11	.63	.05	.29	.01
6	6.06	.57	.05	.25	.00
7	5.38	.54	.04	.23	.00
8	4.88	.51	.03	.22	.00
9	4.51	.50	.03	.21	.00
10	4.20	.48	.03	.20	.00
11	3.95	.47	.03	.19	.00
13	3.53	.44	.02	.18	.00
15	3.20	.41	.02	.16	.00
17	2.92	.39	.02	.15	.00
19	2.68	.36	.02	.14	.00
21	2.48	.34	.02	.13	.00
23	2.31	.32	.01	.12	.00
27	2.02	.28	.01	.11	.00
31	1.80	.25	.01	.10	.00
35	1.62	.23	.01	.09	.00

TABLE C-42. C-121 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT C 121 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	27.88	1.41	.24	.79	.02
6	23.77	1.26	.20	.69	.01
7	20.93	1.17	.18	.62	.01
8	18.89	1.13	.16	.58	.01
9	17.36	1.12	.14	.55	.01
10	16.16	1.11	.13	.53	.01
11	15.18	1.11	.12	.52	.01
13	13.62	1.10	.10	.49	.01
15	12.38	1.07	.09	.47	.01
17	11.34	1.03	.08	.44	.01
19	10.47	.98	.08	.41	.01
21	9.71	.94	.07	.39	.01
23	9.06	.89	.06	.37	.01
27	7.97	.80	.06	.33	.01
31	7.12	.73	.05	.30	.01
35	6.43	.67	.04	.27	.00

TABLE C-43. C-130A-E WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT C 130 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	2.96	1.88	.92	.11	.15
6	2.82	1.79	.81	.10	.14
7	2.73	1.75	.74	.09	.13
8	2.67	1.71	.69	.09	.12
9	2.62	1.68	.64	.08	.12
10	2.57	1.65	.61	.08	.11
11	2.51	1.62	.58	.08	.11
13	2.38	1.54	.52	.07	.10
15	2.23	1.44	.48	.07	.09
17	2.09	1.35	.44	.06	.08
19	1.95	1.26	.40	.06	.08
21	1.83	1.18	.37	.06	.07
23	1.71	1.11	.35	.05	.07
27	1.52	.98	.30	.05	.06
31	1.36	.88	.27	.04	.05
35	1.23	.79	.24	.04	.05

TABLE C-44. C-130H WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT C130 H NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	1.21	.91	1.03	.08	.14
6	1.14	.87	.88	.07	.12
7	1.10	.85	.77	.06	.11
8	1.07	.83	.70	.06	.10
9	1.05	.82	.64	.05	.10
10	1.03	.81	.59	.05	.09
11	1.00	.79	.55	.05	.09
13	.94	.75	.48	.04	.08
15	.89	.70	.43	.04	.07
17	.83	.66	.39	.03	.07
19	.77	.62	.36	.03	.06
21	.72	.58	.33	.03	.06
23	.68	.54	.30	.03	.05
27	.60	.48	.26	.02	.05
31	.54	.43	.23	.02	.04
35	.48	.39	.21	.02	.04

TABLE C-45. C-135B WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT C 135B NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	6.03	7.43	1.44	.24	.20
6	5.77	7.13	1.22	.21	.18
7	5.67	7.04	1.07	.18	.16
8	5.70	7.10	.96	.16	.15
9	5.80	7.24	.88	.15	.15
10	5.92	7.40	.81	.13	.14
11	6.01	7.53	.75	.12	.13
13	6.06	7.61	.67	.11	.13
15	5.96	7.49	.60	.10	.12
17	5.76	7.25	.54	.09	.11
19	5.52	6.95	.50	.08	.10
21	5.26	6.63	.46	.07	.10
23	5.00	6.31	.43	.07	.09
27	4.53	5.71	.37	.06	.08
31	4.11	5.18	.33	.05	.07
35	3.75	4.73	.30	.05	.07

TABLE C-46. C-141 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT C 141 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	4.81	3.90	.76	.06	.11
6	4.47	3.63	.64	.05	.10
7	4.31	3.51	.55	.04	.09
8	4.26	3.47	.49	.04	.08
9	4.27	3.49	.45	.03	.08
10	4.30	3.52	.41	.03	.08
11	4.33	3.54	.38	.03	.07
13	4.30	3.52	.34	.03	.07
15	4.18	3.43	.30	.02	.07
17	4.02	3.30	.28	.02	.06
19	3.83	3.15	.25	.02	.06
21	3.64	2.99	.23	.02	.05
23	3.46	2.84	.22	.02	.05
27	3.11	2.56	.19	.01	.05
31	2.82	2.32	.17	.01	.04
35	2.57	2.11	.15	.01	.04

TABLE C-47. F-4C-D WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT F 4 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	1.31	.23	.34	.06	.08
6	1.19	.21	.29	.05	.07
7	1.12	.21	.26	.04	.06
8	1.08	.20	.23	.04	.06
9	1.06	.20	.21	.04	.05
10	1.05	.20	.20	.03	.05
11	1.04	.20	.18	.03	.05
13	1.01	.20	.16	.03	.04
15	.97	.19	.15	.03	.04
17	.93	.18	.13	.02	.04
19	.88	.17	.12	.02	.03
21	.83	.16	.11	.02	.03
23	.78	.16	.11	.02	.03
27	.70	.14	.09	.02	.02
31	.63	.13	.08	.02	.02
35	.57	.11	.07	.01	.02

TABLE C-48. F-4E WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT F 4 E NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	.99	.17	.48	.05	.09
6	.89	.16	.41	.05	.07
7	.83	.15	.36	.04	.06
8	.80	.15	.32	.04	.06
9	.78	.15	.29	.03	.05
10	.76	.15	.27	.03	.05
11	.75	.15	.25	.03	.05
13	.72	.14	.22	.03	.04
15	.69	.14	.20	.02	.04
17	.65	.13	.18	.02	.04
19	.62	.13	.16	.02	.03
21	.58	.12	.15	.02	.03
23	.55	.11	.14	.02	.03
27	.49	.10	.12	.01	.03
31	.44	.09	.11	.01	.02
35	.40	.08	.10	.01	.02

TABLE C-49. F-5A WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT F 5A NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	2.66	.34	.07	0.00	.04
6	2.40	.32	.06	0.00	.03
7	2.25	.30	.05	0.00	.03
8	2.15	.30	.05	0.00	.03
9	2.08	.29	.04	0.00	.02
10	2.03	.29	.04	0.00	.02
11	1.98	.28	.04	0.00	.02
13	1.87	.27	.03	0.00	.02
15	1.77	.26	.03	0.00	.02
17	1.66	.25	.03	0.00	.02
19	1.55	.23	.02	0.00	.01
21	1.46	.22	.02	0.00	.01
23	1.37	.21	.02	0.00	.01
27	1.22	.18	.02	0.00	.01
31	1.10	.17	.02	0.00	.01
35	.99	.15	.02	0.00	.01

TABLE C-50. F-15 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT F 15 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	.76	.11	.31	.01	.07
6	.68	.10	.27	.01	.06
7	.64	.09	.24	.01	.06
8	.62	.09	.22	.01	.05
9	.60	.08	.20	.01	.05
10	.60	.08	.19	.01	.05
11	.59	.08	.18	.01	.04
13	.57	.08	.17	.01	.04
15	.55	.08	.15	.01	.04
17	.52	.07	.14	.01	.04
19	.50	.07	.13	.01	.03
21	.47	.06	.12	.00	.03
23	.44	.06	.11	.00	.03
27	.40	.05	.10	.00	.03
31	.36	.05	.09	.00	.02
35	.33	.04	.08	.00	.02

TABLE C-51. F-16 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT F-16 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	.24	.03	.26	.00	.02
6	.21	.03	.23	.00	.02
7	.21	.03	.20	.00	.02
8	.22	.03	.18	.00	.02
9	.24	.03	.17	.00	.02
10	.26	.04	.16	.00	.02
11	.29	.04	.15	.00	.02
13	.32	.04	.14	.00	.02
15	.34	.05	.13	.00	.02
17	.34	.05	.12	.00	.02
19	.34	.05	.12	.00	.02
21	.33	.04	.11	.00	.02
23	.32	.04	.10	.00	.02
27	.30	.04	.09	.00	.01
31	.27	.04	.08	.00	.01
35	.25	.03	.07	.00	.01

TABLE C-52. F-100 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT F 100 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	2.12	1.59	.27	.02	.08
6	2.01	1.54	.23	.02	.07
7	1.95	1.51	.20	.02	.06
8	1.91	1.49	.18	.02	.06
9	1.88	1.47	.17	.02	.05
10	1.85	1.46	.16	.01	.05
11	1.82	1.44	.15	.01	.05
13	1.73	1.38	.13	.01	.04
15	1.63	1.30	.12	.01	.04
17	1.53	1.22	.11	.01	.04
19	1.43	1.15	.10	.01	.03
21	1.34	1.08	.09	.01	.03
23	1.26	1.01	.09	.01	.03
27	1.12	.90	.08	.01	.03
31	1.00	.81	.07	.01	.02
35	.91	.73	.06	.01	.02

TABLE C-53. F-101 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT F 101 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	1.66	1.15	.54	.08	.10
6	1.51	1.07	.46	.07	.09
7	1.43	1.02	.41	.06	.08
8	1.38	1.01	.37	.06	.07
9	1.37	1.01	.33	.05	.07
10	1.36	1.01	.31	.05	.06
11	1.35	1.02	.28	.04	.06
13	1.32	1.01	.25	.04	.05
15	1.27	.98	.22	.03	.05
17	1.21	.94	.20	.03	.04
19	1.15	.89	.18	.03	.04
21	1.09	.85	.17	.03	.04
23	1.03	.80	.16	.02	.03
27	.93	.72	.14	.02	.03
31	.83	.66	.12	.02	.03
35	.76	.60	.11	.02	.02

TABLE C-54. F-102 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT F 102 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	.81	.57	.27	.04	.05
6	.74	.53	.23	.04	.04
7	.70	.51	.20	.03	.04
8	.69	.50	.18	.03	.03
9	.68	.51	.16	.03	.03
10	.68	.52	.15	.02	.03
11	.69	.52	.14	.02	.03
13	.68	.52	.12	.02	.03
15	.66	.51	.11	.02	.02
17	.63	.49	.10	.02	.02
19	.61	.47	.09	.01	.02
21	.58	.45	.08	.01	.02
23	.55	.43	.08	.01	.02
27	.49	.39	.07	.01	.02
31	.44	.35	.06	.01	.01
35	.41	.32	.05	.01	.01

TABLE C-55. F-104C WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT F 104A NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	2.08	.42	.23	.04	.07
6	2.00	.40	.21	.04	.06
7	1.96	.40	.19	.03	.06
8	1.92	.39	.18	.03	.05
9	1.90	.39	.17	.03	.05
10	1.87	.38	.16	.03	.05
11	1.83	.38	.15	.03	.05
13	1.74	.36	.14	.03	.04
15	1.64	.34	.12	.02	.04
17	1.53	.32	.11	.02	.04
19	1.44	.30	.11	.02	.03
21	1.34	.28	.10	.02	.03
23	1.26	.26	.09	.02	.03
27	1.12	.23	.08	.02	.03
31	1.00	.21	.07	.01	.02
35	.91	.19	.06	.01	.02

TABLE C-56. F-104C WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT F104G NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	1.27	.26	.29	.03	.06
6	1.21	.25	.26	.03	.06
7	1.18	.25	.23	.03	.05
8	1.15	.24	.21	.02	.05
9	1.13	.24	.20	.02	.05
10	1.11	.24	.18	.02	.04
11	1.08	.23	.17	.02	.04
13	1.03	.22	.16	.02	.04
15	.96	.21	.14	.02	.04
17	.90	.19	.13	.01	.03
19	.84	.18	.12	.01	.03
21	.79	.17	.11	.01	.03
23	.74	.16	.10	.01	.03
27	.65	.14	.09	.01	.02
31	.59	.13	.08	.01	.02
35	.53	.12	.07	.01	.02

TABLE C-57. F-105 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT F 105 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	2.07	1.24	.45	.06	.07
6	1.99	1.20	.39	.05	.06
7	1.94	1.17	.35	.04	.06
8	1.92	1.16	.32	.04	.05
9	1.90	1.15	.29	.04	.05
10	1.87	1.14	.27	.03	.05
11	1.85	1.12	.25	.03	.05
13	1.77	1.07	.23	.03	.04
15	1.68	1.02	.20	.02	.04
17	1.58	.96	.18	.02	.04
19	1.48	.90	.17	.02	.03
21	1.39	.85	.16	.02	.03
23	1.31	.79	.15	.02	.03
27	1.16	.71	.13	.02	.03
31	1.04	.64	.11	.01	.02
35	.95	.58	.10	.01	.02

TABLE C-58. F-105 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT F 106 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	1.41	1.00	.53	.04	.09
6	1.29	.92	.45	.04	.08
7	1.22	.89	.40	.03	.07
8	1.20	.88	.35	.03	.06
9	1.19	.89	.32	.03	.06
10	1.19	.90	.29	.02	.05
11	1.19	.91	.27	.02	.05
13	1.18	.92	.24	.02	.04
15	1.15	.90	.21	.02	.04
17	1.10	.87	.19	.02	.04
19	1.05	.83	.18	.02	.03
21	1.00	.79	.16	.01	.03
23	.95	.75	.15	.01	.03
27	.86	.68	.13	.01	.03
31	.78	.62	.12	.01	.02
35	.71	.56	.11	.01	.02

TABLE C-59. F-111A WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT F 111A NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	2.80	2.10	.79	.12	.11
6	2.63	2.01	.67	.10	.09
7	2.54	1.96	.59	.08	.09
8	2.48	1.94	.53	.07	.08
9	2.43	1.92	.48	.07	.07
10	2.39	1.90	.44	.06	.07
11	2.35	1.88	.41	.06	.07
13	2.24	1.81	.36	.05	.06
15	2.12	1.72	.32	.04	.05
17	1.99	1.62	.29	.04	.05
19	1.87	1.52	.27	.03	.05
21	1.76	1.43	.24	.03	.04
23	1.65	1.35	.23	.03	.04
27	1.47	1.20	.20	.02	.04
31	1.32	1.08	.18	.02	.03
35	1.19	.98	.15	.02	.03

TABLE C-60. F-111D WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT F111D NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	2.10	.71	1.17	.02	.14
6	1.98	.68	1.00	.02	.12
7	1.91	.67	.89	.01	.11
8	1.86	.66	.80	.01	.10
9	1.83	.66	.73	.01	.09
10	1.80	.65	.67	.01	.09
11	1.76	.64	.62	.01	.08
13	1.68	.62	.55	.01	.08
15	1.59	.59	.49	.01	.07
17	1.49	.55	.44	.01	.06
19	1.40	.52	.40	.01	.06
21	1.32	.49	.37	.01	.05
23	1.24	.46	.34	.01	.05
27	1.10	.41	.30	.00	.04
31	.99	.37	.26	.00	.04
35	.89	.33	.23	.00	.03

TABLE C-61. F-111F WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT F111F NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	2.14	.73	1.17	.02	.14
6	2.01	.69	1.01	.02	.12
7	1.93	.68	.89	.01	.11
8	1.88	.67	.80	.01	.10
9	1.84	.66	.73	.01	.09
10	1.81	.65	.67	.01	.09
11	1.78	.65	.62	.01	.08
13	1.69	.62	.55	.01	.08
15	1.60	.59	.49	.01	.07
17	1.50	.56	.44	.01	.06
19	1.41	.52	.40	.01	.06
21	1.32	.49	.37	.01	.05
23	1.24	.46	.34	.01	.05
27	1.10	.41	.30	.00	.04
31	.99	.37	.27	.00	.04
35	.89	.34	.23	.00	.03

TABLE C-62. KC-135A WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT KC 135A NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	8.86	7.08	.85	.06	.18
6	8.02	6.42	.72	.05	.16
7	7.48	6.00	.63	.04	.15
8	7.12	5.71	.57	.04	.14
9	6.87	5.52	.52	.03	.13
10	6.67	5.36	.49	.03	.12
11	6.50	5.23	.46	.03	.12
13	6.16	4.96	.41	.03	.11
15	5.81	4.69	.38	.02	.10
17	5.47	4.41	.35	.02	.10
19	5.14	4.15	.32	.02	.09
21	4.84	3.91	.30	.02	.09
23	4.56	3.68	.28	.02	.08
27	4.07	3.29	.24	.02	.07
31	3.67	2.96	.22	.01	.06
35	3.33	2.69	.20	.01	.06

TABLE C-63. O-1 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT O 1 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	.69	.05	.00	.02	0.00
6	.59	.04	.00	.02	0.00
7	.53	.04	.00	.02	0.00
8	.48	.04	.00	.02	0.00
9	.44	.04	.00	.02	0.00
10	.41	.04	.00	.02	0.00
11	.39	.04	.00	.02	0.00
13	.35	.04	.00	.02	0.00
15	.32	.03	.00	.01	0.00
17	.30	.03	.00	.01	0.00
19	.27	.03	.00	.01	0.00
21	.25	.03	.00	.01	0.00
23	.24	.03	.00	.01	0.00
27	.21	.03	.00	.01	0.00
31	.19	.02	.00	.01	0.00
35	.17	.02	.00	.01	0.00

AD-A067 262 CIVIL AND ENVIRONMENTAL ENGINEERING DEVELOPMENT OFFIC--ETC F/G 13/2
AIRCRAFT AIR POLLUTION EMISSION ESTIMATION TECHNIQUES - ACEE.(U)
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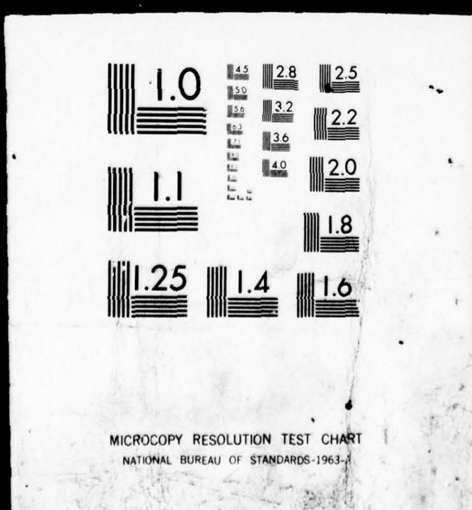
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MICROCOPY RESOLUTION TEST CHART
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TABLE C-64. O-2 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT O 2 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	1.42	.14	.01	.07	.00
6	1.24	.12	.00	.06	.00
7	1.13	.11	.00	.06	.00
8	1.07	.11	.00	.05	.00
9	1.03	.11	.00	.05	.00
10	1.01	.11	.00	.05	.00
11	.99	.12	.00	.05	.00
13	.96	.12	.00	.05	.00
15	.92	.12	.00	.05	.00
17	.88	.11	.00	.05	.00
19	.84	.11	.00	.05	.00
21	.79	.11	.00	.05	.00
23	.75	.10	.00	.04	.00
27	.68	.09	.00	.04	0.00
31	.61	.08	.00	.04	0.00
35	.56	.08	.00	.03	0.00

TABLE C-65. OV-10 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT OV10 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	.17	.04	.11	.01	.01
6	.15	.04	.09	.01	.01
7	.14	.04	.08	.01	.01
8	.13	.04	.08	.01	.01
9	.13	.04	.07	.00	.01
10	.13	.04	.07	.00	.01
11	.13	.04	.07	.00	.01
13	.14	.04	.07	.00	.01
15	.13	.04	.06	.00	.01
17	.13	.04	.06	.00	.01
19	.12	.04	.06	.00	.01
21	.12	.03	.05	.00	.01
23	.11	.03	.05	.00	.01
27	.10	.03	.04	.00	.01
31	.09	.03	.04	.00	.01
35	.09	.03	.04	.00	.00

TABLE C-66. T-33 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT T 33 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	1.85	.24	.05	.01	.02
6	1.65	.22	.04	.01	.02
7	1.54	.21	.04	.01	.02
8	1.46	.20	.03	.01	.02
9	1.40	.19	.03	.01	.01
10	1.36	.19	.03	.01	.01
11	1.32	.18	.03	.01	.01
13	1.23	.17	.02	.01	.01
15	1.15	.16	.02	.01	.01
17	1.08	.15	.02	.01	.01
19	1.01	.14	.02	.01	.01
21	.94	.13	.02	.01	.01
23	.88	.13	.02	.01	.01
27	.78	.11	.01	.00	.01
31	.70	.10	.01	.00	.01
35	.63	.09	.01	.00	.01

TABLE C-67. T-37 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT T 37 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	1.00	.13	.02	.00	.01
6	.90	.12	.02	.00	.01
7	.85	.11	.02	.00	.01
8	.81	.11	.02	.00	.01
9	.78	.11	.02	.00	.01
10	.76	.10	.01	.00	.01
11	.74	.10	.01	.00	.01
13	.70	.10	.01	.00	.01
15	.66	.09	.01	.00	.01
17	.61	.09	.01	.00	.01
19	.57	.08	.01	.00	.01
21	.54	.08	.01	.00	.01
23	.50	.07	.01	.00	.00
27	.45	.06	.01	.00	.00
31	.40	.06	.01	.00	.00
35	.36	.05	.01	.00	.00

TABLE C-68. T-38 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT T 38 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	2.52	.36	.05	0.00	.03
6	2.31	.34	.04	0.00	.02
7	2.20	.33	.04	0.00	.02
8	2.12	.32	.03	0.00	.02
9	2.07	.31	.03	0.00	.02
10	2.03	.31	.03	0.00	.02
11	1.99	.31	.03	0.00	.02
13	1.90	.30	.03	0.00	.02
15	1.80	.28	.02	0.00	.01
17	1.69	.27	.02	0.00	.01
19	1.59	.25	.02	0.00	.01
21	1.49	.24	.02	0.00	.01
23	1.40	.22	.02	0.00	.01
27	1.25	.20	.02	0.00	.01
31	1.12	.18	.01	0.00	.01
35	1.01	.16	.01	0.00	.01

TABLE C-69. T-39 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT T 39 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER) CO	HC	NOX	PT	SO2
5	.64	.08	.03	.00	.01
6	.58	.07	.03	.00	.01
7	.54	.07	.03	.00	.01
8	.52	.07	.02	.00	.01
9	.50	.06	.02	.00	.01
10	.49	.06	.02	.00	.01
11	.47	.06	.02	0.00	.01
13	.45	.06	.02	0.00	.01
15	.42	.05	.02	0.00	.01
17	.39	.05	.02	0.00	.01
19	.37	.05	.01	0.00	.01
21	.34	.04	.01	0.00	.01
23	.32	.04	.01	0.00	.01
27	.29	.04	.01	0.00	.01
31	.26	.03	.01	0.00	.00
35	.23	.03	.01	0.00	.00

TABLE C-70. T-41 WORST CASE DOWNFIELD CONCENTRATIONS

AIRCRAFT T 41 NORMAL 1 LTO

ATMOSPHERIC CONDITIONS WORST CASE
STABILITY CATEGORY 6
WIND SPEED (METERS/SECOND) 1.00
WIND DIRECTION TAILWIND
TEMPERATURE (F) 38.00
MIXING DEPTH (METERS) 115.00

DISTANCE FROM START OF TAKE-OFF (KM)	RECEPTOR CONCENTRATION DATA (MICROGRAMS/CU. METER)				
	CO	HC	NOX	PT	SO2
5	.73	.07	.00	.03	0.00
6	.64	.06	.00	.03	0.00
7	.57	.06	.00	.03	0.00
8	.53	.06	.00	.03	0.00
9	.50	.05	.00	.03	0.00
10	.48	.05	.00	.02	0.00
11	.46	.05	.00	.02	0.00
13	.43	.05	.00	.02	0.00
15	.40	.05	.00	.02	0.00
17	.37	.05	.00	.02	0.00
19	.35	.04	.00	.02	0.00
21	.33	.04	.00	.02	0.00
23	.31	.04	.00	.02	0.00
27	.27	.04	.00	.02	0.00
31	.25	.03	.00	.01	0.00
35	.22	.03	.00	.01	0.00

APPENDIX D

EXAMPLE ACEE APPLICATION

Super Air Force Base is a UPT training base. An environmental assessment must be made for increased number of training missions to be flown the next fiscal year. The downfield pollution concentrations must also be determined for Home City. Home City is citing the AF base for its CO concentrations during the morning missions.

The increase in aircraft operations is as follows:

	Increased LTOs (per year)	Increased TGOs (per year)
T-37	1,500	250
T-38	1,000	200

These increased T-38 LTOs will result in a 5-minute queue delay before takeoff.

STEP 1 - CURRENT AIRCRAFT OPERATIONS

From base operations, the following operational data were collected for the current fiscal year.

	LTOs (per year)	TGOs (per year)
T-37	15,000	2895
T-38	16,525	2982

STEP 2 - MODIFY EMISSIONS FOR THE QUEUING

Since every item in the LTO cycle compared favorably with the ACEE time in mode, the ACEE LTO cycle is used. The only emissions that have to be added are the queue time.

The idle engine mode is used during the queue. Locating the idle emission factors in the Table 1, the emissions per 5-minute queue can be calculated:

Engine J85-5:

EGM = Idle

NOEG = 2

TIMOD = 5 min x 60 s/min = 300 s

Emissions (POL) (g) = FLFLW(idle)(kg/s) x TIMOD(s) X EMFAC(idle, CO)

CO	3,043.8	0.057	300	178.0
H_xC_y	513.0	0.057	300	30.0
NO_x	22.2	0.057	300	1.3
PM	0.05	0.057	300	0.003
SO_x	17.1	0.057	300	1.0

These factors are added to the LTO cycle emissions. Thus, the LTO emissions are presented below:

	CO	C_xH_y	NO_x	PM	SO_x
LTO Total (metric tons) (From Table A-26	$4.0X10^{2}$	$6.1X10^{3}$	$6.0X10^{-4}$	$2.3x10^{-6}$	$3.5x10^{-4}$
+ Queue Emissions (metric tons)	$3.0x10^{-3}$	$5.1x10^{-4}$	$2.2x10^{-5}$	$5.0x10^{-8}$	$1.7x10^{-5}$
Modified LTO Emissions (metric tons)	$4.3x10^{-2}$	$6.6x10^{-3}$	$6.2x10^{-4}$	$2.4x10^{-6}$	$3.7x10^{-4}$

Note: Queue emissions were converted to metric tons.

STEP 3 - CALCULATE ANNUAL POLLUTANT EMISSIONS

The number of operations LTO and TGO are multiplied by the emission factors. The annual emissions computed by this process are presented below:

		Current Yr (ops/yr)	+	Additional (ops/yr)	=	Total (ops/yr)
T-37	(LTOs)	15,000		1,500	=	16,500
	(TGOs)	1,895		250	=	2,145
T-38	(LTOs)	16,525		1,000	=	17,525
	(TGOs)	1,982		800	=	2,182

	CO	C_xH_y	NO_x	PM	SO_x
T-37 (LTOs/yr)	16,500	16,500	16,500	16,500	16,500
x Pollutant Emissions (metric tons/LTO) (from Table A-[redacted]) A-25)	$1.5x10^{-2}$	$2.0x10^{-3}$	$3.0x10^{-4}$	$5.6x10^{-5}$	$1.4x10^{-4}$
T-37 Pollutant Annual Emissions (metric tons/yr)	247.0	33.0	5.0	0.9	2.3

Projected Pollutant Annual Emissions (metric tons)

	CO	C_xH_y	NO_x	PM	SO_x
T-37 (LTOs)	247.5	33.0	5.0	0.9	2.3
T-37 (TGOs)	4.5	0.3	0.3	0.0	0.1
T-38 (LTOs)	701.0	106.9	10.5	0.0	6.1
T-38 (TGOs)	8.5	0.5	0.4	0.0	0.2
Total A/C Emissions	961.5	140.7	16.2	0.9	8.7

Change in Emissions

The H_xC_y, NO_x, PM and SO_x emissions are below the 227 metric tons per year. However, CO annual emissions exceed 227 metric tons. Additional analysis would be required. This should include a comparison with base, local and regional emission inventories. Aircraft nationwide contribute only one percent of the total annual emissions. Remember, ACEE is a screening device; closer examination might or might not predict an air pollution problem from aircraft.

STEP 4 - AIR QUALITY ANALYSIS

The greatest number of aircraft operations during a one-hour period is found from aircraft operations records. An interview with the operations personnel will give a good estimate of greatest number LTO/hour. An interview is a good method to gather the data for quick assessments. The maximum number of LTOs/hour is 22 at 0800 hrs which includes 10 T-37s and 11 T-38s.

The particulate dispersion curve is used to make a quick assessment. Using Table 2, the T-37 and T-38 group number is 2 for CO. The T-38 group number is 3. Home City is located 30 km downfield from start of runway roll. The worst case downfield CO concentration is 0.4 mq/m^3 (T-37) and 1.1 mg/m^3 (T-38) (Figure 4). The one-hour pollution concentrations are:

$$(0.4\ \mu g/m^3/LTO) \times (10\ \text{T-37 LTOs/hr}) = 4.0\ \mu g/m^3$$
$$(1.1\ \mu g/m^3/LTO) \times (11\ \text{T-38 LTOs/hr}) = 12.1\ \mu g/m^3$$
$$\text{Total CO at 30 km} = 16.1\ \mu g/m^3$$

The worst case one-hour CO ground level concentration at 30 km downfield (Home City) is 16.1 mg/m^3 using the downfield dispersion curves.

The aircraft pollution concentration T-37 and T-38 tables in Appendix C can be used to make more accurate calculations at the 30-km point. Using the concentration values in the appendix, the 30-km downfield CO concentrations are computed:

$(0.41\ \mu g/m^3/\text{T-37 LTO}) \times (10\ \text{T-37 LTOs/hr}) = 4.1\ \mu g/m^3$
$(1.15\ \mu g/m^3/\text{T-38 LTO}) \times (11\ \text{T-38 LTOs/hr}) = \underline{12.6\ \mu g/m^3}$

Total CO at 34 km $16.7\ \mu g/m^3$

The 31-km worst case CO concentration is $16.7\ \mu g/m^3$ or $0.01\ \mu g/m^3$ using the downfield concentration tables (C-67 and C-68).

The primary and secondary NAAQS CO are 40 mg/m^3 maximum one-hour concentrations not to be exceeded more than once per year. The maximum one-hour concentration calculated using ACEE was 0.01 mg/m^3. The computation is far less than the primary and secondary NAAQS for CO. Therefore, the ACEE result is valid and predicts that aircraft CO concentration contributions are negligible over Home City. ACEE predicts aircraft concentrations only. Other base air pollution sources are not considered for analysis.

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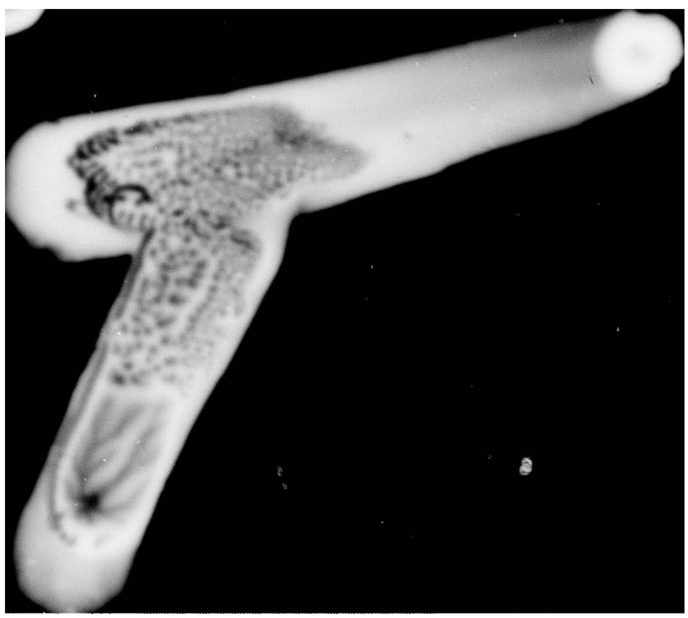

AD-A067 262L ABERDEEN PROVING GROUND MD FLD 9
DIRECT DETERMINATION OF TOTAL ZINC IN MIXED PAINT PIGMENTS(U)
JUN 55 M SWANN
UNCLASSIFIED LSD R 249 DOD ONLY

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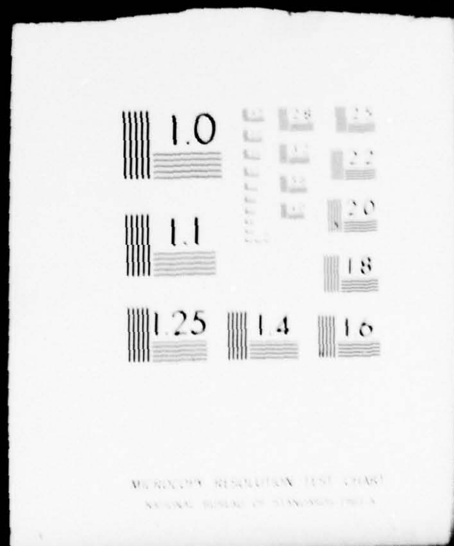

SUPPLEMENTARY

INFORMATION

AD-A067262

ERRATA

CEEDO-TR-78-33 - Aircraft Air Pollution
Emission Estimation Techniques - ACEE

HQ AFESC/RDVC
Tyndall AFB FL 32403

1. Page No. 23 - Change "Using Figure 6" to read "Using Figure 5."
   - Change all "mg/m^3 to read "μ/m^3."

   Page No. 54 - Change "1.2 E - 02 = 1.2×10^{-1} = 0.02" to read "1.2 E - 02 = 1.2×10^{-2} = 0.012."
   - Change "1.2 E + 02 = 1.2×10^{2} = 20" to read "1.2 E + 02 = 120.0."

   Page No. 100 - Change "(From Table A-41)" to read "(From Table A-26)."
   - Change "(from Table A-40)" to read "(from Table A-25)."

   Page No. 101 - Change "Change in Emissions (Percent)" to read "Change in Emissions."
   - Change all "mg/m^3" to read "$\mu g/m^3$."

   Page No. 102 - Change all "mg/m^3" to read "$\mu g/m^3$" except for "40 mg/m^3" and "0.02 mg/m^3."

2. This errata is unclassified.

Harold A Scott

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Project Officer